PROCEEDINGS

OF THE

NATIONAL ACADEMY OF SCIENCES, INDIA

1963

VOL. XXXIII SECTION—B PART I

SYMPOSIUM ON ECOLOGICAL PROBLEMS IN THE TROPICS

NATIONAL ACADEMY OF SCIENCES, INDIA
ALLAHABAD

The *Proceedings of the National Academy of Sciences, India*, is published in two sections : Section A (Physical Sciences) and Section B (Biological Sciences). Four parts of each section are published annually since 1960).

The Editorial Board in its work of examining papers received for publication is assisted, in an honorary capacity, by a large number of distinguished scientists. Papers are accepted from members of the Academy *in good standing*. In case of a joint paper, one of the authors must be a member of the Academy. The Academy assumes no responsibility for the statements and opinions advanced by the authors. The papers must conform strictly to the rules for publication of papers in the *Proceedings*. A total of 50 reprints is supplied free of cost to the author or authors. The authors may have any reasonable number of additional reprints at cost price, provided they give prior intimation while returning the proof.

Communications regarding contributions for publication in the *Proceedings*, books for review, subscriptions etc. should be sent to the General Secretary, National Academy of Sciences, India, Lajpatrai Road, Allahabad-2 (India).

Annual Subscription for both Sections : Rs. 65 ; for each Section : Rs. 35 (including Annual Number) ; Single Copy: Rs. 7.50 ; Annual Number Rs. 5

PROCEEDINGS
OF THE
NATIONAL ACADEMY OF SCIENCES
INDIA
1963

VOL. XXXIII SECTION - B PART I

THE TASK BEFORE THE TROPICAL ECOLOGIST WITH SPECIAL REFERENCE TO INDIA

By
HARRY G. CHAMPION
FAO, Bangkok

Fundamental and Applied Research. A review of the present position with regard to our knowledge of the ecology of any part of the tropics inevitably leads to the recognition of the great gaps and to the importance and urgency of focussing attention and effort on steps to secure a more complete picture. The importance lies in the intimate bearing of ecology on the problems of assessing the potentialities of the many very different site types for the many purposes for which we now need to use them. The urgency lies in the fact that populations are increasing everywhere to the point at which all the available land is doubtfully able to meet all the needs. Dominant among these needs is food followed by other products of intensely cultivated crops such as rubber and various fibres. Next comes the protection of climatic values, soil, and water though much of the land allocated to this usage can also be used—subject to appropriate restrictions—to contribute to food supplies, especially through controlled grazing, or to other needs as by regulated fuel or timber fellings. A large area is at present still under forest but this has tended hitherto to be viewed as a general land reserve, he forest being at present useful—or in many places essential—for supplying timber or housing and other construction works, fuel for heating and cooking, and also to an increasing extent wood-fibre as raw material for the paper, rayon and other industries. Looking ahead, it seems likely that the forests, which tend to be on the steeper slopes and over the upper parts of the major river catchments, are likely to be rated even higher for their protective than for their productive function, and their retention accepted as a necessity in the general interest. Furthermore, many of the forest areas are to an increasing extent coming to be valued also for recreational purposes, and some of them for retention in the form we have inherited them, with as little interference as possible.

As soon as we have allocated land for any use or uses, we then introduce or encourage activities aiming at raising its productivity for that purpose, be it for food, raw materials, timber, water, or recreation, thereby interfering with the natural equilibrium which had been, or would in time be reached between biome and

site. It is the function of ecology to study these equilibria over their whole range of variety, the processes leading to them, and the consequences of disturbances of all kinds. With our limited research facilities, it is evident that the two lines of research, the "applied" and the more fundamental (admittedly merging), have both to be prosecuted, each helping and stimulating the other. The "applied" ecologist will always be under pressure to speed up his programme by working mainly on a limited selection of the most promising treatment under conditions most representative of the artificial biome with which he deals. The independent ecologist will more usually be seeking the underlying causes that lead to results such as his confrere is obtaining in his experiments, and the processes going on in nature with a minimum of interference. Investigation of the changes which the biome, especially the vegetation, bring about on the physical and chemical factors—and the biological factors also for that matter—of the site it occupies, and the time factors involved, may be particulary illuminating. The vastness of the field to be covered by ecological research is such that one requires some basis on which to decide priorities. One may be so bold as to suggest that the ecology of modified, "managed", or artificial biocoenoses has become more important than that of more or less "natural" ones, if only because the latter form today so very small a proportion of the whole.

Water Relations. An outstanding instance of the principle enunciated above is the need for more study of the water relations of the major biocoenoses. Scientists and administrators have only relatively recently come to realise how universally important, indeed, often critical, has become the question of supply and demand for water. Thus the provision of running water as a step in raising standards of housing and living at once greatly increases per caput consumption. One water catchment after another is taken up to meet these new demands, and there is an immediate call for information on which to base their management. In any case there is urgent need to know what effect the covering vegetation has on the quantity and quality of water that can be collected from the area. Enough has already been done to demonstrate how complex this effect is, and to supply indications of the direction and magnitude of some of the factors, but by far the greater part of the work has been done with temperate climates and soils. For the tropics we have only isolated investigations irregularly scattered as to time and space, utterly inadequate for forming more than wide generalisations as to what may happen over a period of years in view of observations made under other circumstances. What is needed is clearly a team approach working to a carefully thought out programme on the bigger technological scale, supplemented by attacks by individuals or small groups, linked with the team or independent, through basic research on single factors or simple groups of factors.

Until recently, little attention has been given to studying the limitations to growth and production of vegetation, both natural and artificial, imposed by possible shortages of water on sites where there is enough to ensure seasonal growth covering the ground more or less completely and to give "normal" crops and yield. Additional water supplied in the right way at the right time may lead to a very marked increase in dry weight production, *e.g.*, two or three cuttings of grass and fodder crops in place of one, or a similar increase of timber increment. It is obvious that if this additional growth is harvested and removed from the site, there will be an increased drain on the mineral nutrient supply in the soil, and the movement of the extra water in the soil must bring about other changes. Where will these changes end up ?

Water relations as affected by land use. If we know the effect of a mixed forest or herbage cover on the water balance with fire protection and exclusion of cattle, what difference will it make if it is burnt and/or grazed, or replaced by bamboo, tree plantations or grass ? A live issue at the moment is the relative drain of a crop of fast growhng *Eucalyptus*, *Casuarina*, or softwood, as compared with the low forest or scrub wich they often replace ? Incidentally, what are the features that enable these two genera as exotics to attain as much as double or more the height of the indigenous vegetation ? It has been pointed out by Pearsall, that the rate of organic synthesis varies considerably among vegetation types on the same site, or on different sites with the same climate, with strikingly high values for swamp vegetation. We badly need more data on these points for the tropics.

Water relations in arid regions. The complement to studies on water relations where there is a good supply during at least part of the year, are similar studies where water scarcity is the dominating feature. Here, severe competition between species is clearly not for light but for soil moisture. Investigations have been reported (Bhide 1921) on the moisture content of the soil immediately around the root system of different species, but this may reflect either differing intensity of withdrawal by the roots, or different success in establishment on sites of given moisture content, and be further confused by chance factors such as arrival of seed. Ability to withstand drought and to grow with minimum water are factors of the greatest importance both to survival under quasi-natural conditions and to suitability for culture.

Irrigation. We have good deal of information about the immediate effects of irrigation and can give satisfactory explanations for many of them, but there is a lot still to be learned. For the limited areas under tree crops, the effects of varying methods of irrigating on the root system may be critical as indicated by die-back and mortality during periods of water shortage.

Salinity. The salinity of soils under irrigation has frequently been found to increase with or without associated rise of the water-table or even water-logging. In many arid regions, concentration of salts in the soil, particularly at the surface, has a markedly depressing effect on the natural vegetation or crop production. Interference with the vegetation cover of the soil is always liable to accentuate the process. Some useful studies (Basu and Tagare 1943) have been made on remedial treatments with gypsum, sulphur, molasses, and organic manures, but more work is needed both fundamental and applied, and with natural or semi-natural vegetation. Most of the published work on halophytes has been with those of salt marshes rather than those of arid regions.

Humus problems and the soil fauna. It is a familiar feature of the lowland tropics that, with only rare exceptions, the humus is relatively inconspicuous in the soil. Nevertheless, its functions, especially in relation to water and nutrients, are just as important as in temperate regions, with the added feature that at the higher temperatures, it is more readily oxidised and lost, especially by exposure through removal of shade.

The most conspicuous element in the soil fauna is its termite population. Some studies (Shrikhande and Pathak 1953) have been made, but there is room for many more, particularly on the more fundamental aspects. Extremely little has been done in the tropics on other elements of the soil meso- and micro fauna associated with the different natural vegetation types.

Nutrient Relations. In the last decade or so, a great deal of attention has been devoted to tissue analysis of temperate vegetation but only to a much smaller

extent in the tropics (Puri 1954). The difficulty of using soil analysis data for predicting plant reactions has acted as a stimulus, for even when the amounts of the several nutrients in a soil have been determined, the roots may, or may not, be able to absorb what they need. The suggestion is obvious that tissue analysis will show beyond dispute what they have in fact absorbed. Added to this is the fact that plant ash analysis is actually simpler to carry out. The work already done indicates the need for the greatest care in ensuring comparability of material to be analysed, both as regards the part of the plant selected, its situation on the plant and its age and time of collection—for there is much translocation of nutrients within the plant tissues.

Burning. Burning and grazing of the natural vegetation of the tropics beingr the commonest forms of land treatment and use affecting them, and being the majoc causes of their degradation from existing climaxes or seral stages towards thosg climaxes, the nature, extent, and the possible reversability of the changes they bring about, call for closer study both separately and in combination. There has lone been wide recognition of the drastic effects of fire on natural vegetation, though th- extensiveness of the areas over which it has determined the present form and com position is only now coming to be realised. There is the obvious loss of the protective cover to the soil and of the annual contribution of litter that the vegetation would ultimately have made to the humus, both effects in turn adversely affecting moisture retention and percolation, and thereby increasing run-off and erosion. There is also the the surface heating and partial sterilisation of the soil greatly affecting the microflora and fauna and their activities, and there is also the addition of carbonised residues. There is, too, the formation of plant ash which may be washed into the soil to the advantage of surviving or subsequently invading plant growth, but some at least will be lost by wind or surface run-off. And there is inevitably direct loss of combind nitrogen. Once more, a number of isolated studies have been made on particular points, but they are very inadequate in view of the practical importance of the subject. For a proper understanding, further investigations are needed both of individual factors such as those mentioned and of the end effects of the whole complex, on water supplies, soil conservation, dry-weight production and the specific composition of the vegetation. This last point is of considerable economic as well as scientific interest, for it appears to be a matter of chance which particular species are of most value to mankind ; certainly several tree species of high economic value, *e.g.*, *Tectona grandis* and *Shorea robusta* tend to be favoured against their competitors by the occurrence of fire as also are grasses which may be more suitable than broad-leaved shrubs as feed for stock. The long-term aspect is important as effects are likely to be cumulative, and season and frequency of fires are also unquestionably important factors. It might be suggested that the dense growth of *Imperata* grass following forest destruction and buring offers a very interesting field for ecological study.

Grazing. The grazing of domestic stock is largely concentrated on the vegeta- tion types associated with the less favourable moisture regimes, regardless of soil and topography. Outside tropical rain forest, there is today very little natural vegetation indeed that has not been considerably altered by grazing and the other activities that go with it, notably burning and lopping. As in the case of areas long subjected to fire action, it has become very difficult to determine what the original vegetation of the affected areas must have been, though as with the agricultural land, it was almost certainly forest land of sorts. Once more, we lack scientific knowledge of the effects, both immediate and long-term, on the site, of the selective removal of the above-ground plant material, of the differential effects of the seeding and regeneration of the component species, and on the

physical and chemical factors of the soil. It is certain that the grazing will still continue for a long time so that it is an urgent problem to find the best compromise between grazing use, however deleterious, and maintenance of the productive capacity of the site.

Ecological Reserves. Recognizing that extremely little vegetation, even in forests hitherto considered to be "virgin", now exists that has not been much affected directly or indirectly by human activities, there is a lack of knowledge of the potentialities of given sites or existing vegetation types. The ecological status of even the most familiar types is still a matter of speculation and personal opinion. Extremely little is known of the time scale even where the direction of change is discernible. Even the best methods of recording present condition and the changes with time are far from agreed, though some form of indicator quadrat with appropriate sampling procedure seems most promising ; other methods are obviously available among which aerial photography calls for mention. It is suggested that the best situation for these "ecological reserves" or whatever we may call them, may generally be within a larger area which is also receiving a measure of protection, such as a National Park. Modern techniques, among them palynological studies and C 14 dating, make it possible to find out far more about the previous history of such areas than was till recently possible.

The Tropical Rain Forest. Whilst the applied ecology of the moisture deficient habitats should be accorded priority, the special claims of the vegetation type that shows the maximum development known to us, *viz.*, the tropical rain forest, merit and indeed demand much more attention than they are receiving, despite the admittedly considerable difficulties of investigation. The limited number of pioneer ecological studies in it serve to reveal how little we know. The opportunities are rapidlydwindling as the few remaining areas that appear to have been undisturbed so far get "opened up" for one purpose or another—even these areas tend to be restricted to special sites often only doubtfully comparable with what has been destroyed or altered on the more accessible sites. Collection of reliable data of annual total dry weight production, *i.e.*, efficiency of organic synthesis, would be of great interest among the many lines that could be mentioned, though the ways in which these forests maintain themselves is still perhaps the outstanding riddle.

REFERENCES TO LITERATURE

Basu, J. R. and Tagare, V. D. 1943. *Ind. Journ. Agri. Sci.*, **13** : 157-81.

Bhide, R. K. 1921. *Journ. Ind. Bot.* **2** : 27-43.

Puri, G. S. 1954. *Ind. For.* **80** : 700-6 ; *J. Ind. Bot. Soc.*, **33** : 382-93.

Shrikhande, J. G. and Pathak, A. N. 1933. *Ind. Journ. Agri. Sci.*, **21** : 401-8.

TRACE ELEMENT SURVEY OF SOME SOILS OF INDIA

By

G. S. PURI *and* K. LAKSHMINARAYANAN

Central Botanical Laboratory, Allahabad

INTRODUCTION

Trace element survey in soils has attracted the attention of soil scientists all over the world for the past two decades as the trace elements play a key role in controlling not only growth and metabolic processes in plants but also soil fertility through their effect on soil micro-organisms.

The U. S. Department of Agriculture published a comprehensive review on trace elements as early as 1938. The Chilian Nitrate Educational Bureau published a collection of 10,000 abstracts in 1948, on the effects of micro-elements on green plants and animals. In the U. S. S. R., Vinogradov and his colleagues have carried out extensive studies on the Russian soils. There have been numerous reports from the other countries also. In India work on trace element in soils has been started only recently.

While it will be impossible to do justice to the tremendous volume of literature on trace elements that is being published all the world over, an attempt is made here to cover the distribution of some of the more important of the trace elements in Indian soils and for this purposes the trace elements have been divided into two groups:—

(*i*) Those that are essential for plant nutrition like Boron, Copper, Iron, Manganese, Molybdenum and Zinc. The absence or presence of these in subnormal levels in soils results in deficiency diseases.

(*ii*) Those that are not generally considered essential for all species but cause symptoms when present in high concentrations in the soil and are associated with soil infertility. This group includes elements like, Arsenic, Barium, Strontium, Berylilium, Cadmium, Cobalt, Chromium, Fluorine, Iodine, Lithium, Rubidium and Caesium, Nickel, Selenium, Titanium and Vanadium.

Boron :

Boron is very important in plant nutrition ; an excess being toxic to different species. This element has, therefore, been studied extensively in soil samples in numerous countries (Berger 1949 ; Dennis and Dennis 1943 ; Dennis 1947 ; 1948 ; Philips 1953). Boron content of the soil is dependent on the season of study, the time of analysis and the ratio of the extractant used with reference to the soil.

In India, Ghani and Haque (1945) reported a great variation in 2 sets of soil samples from cultivated areas of Bengal the values being 0·54 to 1·75 p. p. m. in one set of 26 samples and 33 to 100 p. p. m. in another set. Bendale, Narayana and Kibe (1951) reported on two sets of surface soils from Bombay State in the West Coast of India values in the range of 1·2 to 0·6 p. p. m. (average of 0·3 p. p. m.) in one set of 12 samples and a range of 1·2 to 16·6 p. p. m. with an average of 7·5 p. p. m. in the other. Dhawan and Dhand (1950) studied the Boron content of a number of soils upto a depth of 14′. They found a higher concentration of Boron in 2-3 to 4-5′ profiles. A higher Boron content but low Ca/B ratios indicated low soil fertility.

Soils with a Ca/B ratio of 500 or higher had good growth of vegetation, while those with ratio of 200 or less were found to be poor or deteriorated soils. Guha (1952) reported the cracking of tuber in potatoes grown in Boron deficient soil ; the condition was due to the high lime content. Satyanarayana (1958) reported on the water-soluble Boron in some desert soils of India. Gandhi and Mehta (1958) estimated the water soluble Boron content of soils of Gujarat and Saurashtra in India. Mandal *et al* (1958) reported on the Boron content of some Bihar soils in India.

Copper :

Copper is essential for many plants for normal growth. A symposium on the Copper metabolism published by John Hopkins Press in 1950 gives important and different aspects of the role of Copper. Gilbert (1952) studied the Copper content of soils throughout the world and formulated certain copper-deficient regions.

Lal, Sahu and Das (1959) reported Copper contents ranging between 11·5 to 20 μg employing *Aspergillus niger* bioassay techniques in some Indian soils. Black soils and peats have the highest amount of Copper while lowest concentrations were recorded in alluvial and red soils.

Bendale, Narayana and Kibe (1951) studied soil Copper content in citrus orchids in the districts of Khandesh, Nasik and Ahmednagar and reported figures in the ranges 3·6 to 8·7 p.p.m. in surface soils and 0·002 to 0·02 p.p.m. in another set.

Iron :

For plant growth iron is needed in very small dosages. The absence of iron causes very acute deficiency symptoms in all higher plants. The obvious symptom of iron deficiency in all plants is chlorosis. It cannot be replaced by any other element. Little is understood about the exact function of iron in chlorophyll synthesis. Iron is known to be the prosthetic group of iron containing enzymes as catalase, the cytochromes, cyto-chrome oxidases etc. which play a key role in respiration.

Iron chlorosis associated with calcareous soil is sometimes due to the conversion of available ferrous salts into unavailable ferric salts in alkaline soil (Thorne and Wallace 1944). Even in arid soils an excess of phosphates may render it unavailable (Chandler and Scarseth 1941). The form in which iron is present in the soil, pH and other physico-chemical characteristics of the soil determine the mobility and availability of the element.

Brito-Muthunayagam and Koshy (1952) found large quantities of iron and Aluminum phosphates in the west coast of India. There was a decrease in both elements as the soil pH increased.

Manganese :

Manganese is an essential element for the growth of most plants and its deficiency is known to result in disturbed carbohydrate metabolism, chlorosis, retarded growth, decrease in ash content and failure to reproduce. The element is attributed a role in aiding an increased assimilation of Ca and Mg and stimulating oxidative processes in plants and in soil (Aso 1907, Kelley 1914). It is also considered to function with Fe in chlorophyll synthesis (McHargue 1922). Nieschlag (1955) showed a doubling of the yields of apparently healthy potatoes in the Manganese-supplied series compared to the controls.

Tea gardens of Ceylon were studied by Eden (1953) who reported Manganese content in the range 170-1210 p.p.m. from Jafna and Kandy. Iyer and Rajagopalan (1936) reported values for soil Manganese content in two samples as 510 and 690 p.p.m. whereas Koch (1946) found the values of 24 to 1204 p.p.m. from 18 surface soils from different parts of Ceylon.

In India, as early as 1906 Hilgard published a report on Manganese content of soils and his values range between 300-5200 p.p.m. Iyer and Rajagopalan (1936) determined the Manganese content of soils from different parts of the country and gave values in the range 96 to 1340 p.p.m. One sub-surface soil had a manganese content of 525 p.p.m. More recently, Bendale, Narayana and Kibe (1951) reported Manganese contents in range 455-928 p.p.m. in top soils in west coast of India. Biswas (1951) reported values in the range 150 to 1556 p.p.m. in virgin soils. Sankarasubramony, Pandalai and Menon (1950) studied cocoanut-growing areas in the Travancore in Southern India and reported an average Manganese content of 10 samples in the range 72·5 to 112·2 p.p.m. Biswas (1951) studied a relationship between Manganese content, soil type and climatic factors. Laterite soils were low in total Manganese and high in exchangeable Manganese. Water-soluble and exchangeable Manganese content decreased from humid to arid climates. In further studies, the same author (Biswas 1953) found that in humid climate, there were large variations within profiles in the Manganese content.

Molybdenum :

Interest has been aroused on the role of Molybdenum as an essential element in plant nutrition only recently. Arnon and Stout (1939) were the first to focus attention on Molybdenum as an essential trace element for higher plants. Whiptail of cauliflowers and N_2- deficiency symptoms in legumes growing in acidic soils have been recognized for a long time though these were not related to any minor element deficiency. Liming acid soil has been the conventional procedure for overcoming these typical symptoms though it was not recognized that liming acid soils made more Molybdenum avilable to the plants and reduced the availability of Fe, Mn, B, Cu and Zn. Wilson and Waring (1948) consider the role of Molybdenum as a catalyst in the reduction of nitrates. In Australia and New Zealand, phenomenal improvement in forage crops was reported on treating the soil with Mn (Anderson 1956). Great interest is attached to Molybdenum surveys especially in soils growing economic crops as vast areas of the world including India are known to be deficient in Molybdenum.

Numerous factors govern the uptake of available Molybdenum from the soil. Sulphur ions were reported to exert a depressing action on Molybdenum uptake (Mulder 1954 ; Stout *et al.* 1951).

Biswas and Dakshinamurti (1955) reported that Molybdenum increased yield of Berum and Reddy and Mehta (1958) reported on the availability of Molybdenum in Gujarat soils from India.

Absolute deficiency of Molybdenum may occur in highly podozolized soils (Anderson and Oertel 1946) or calcareous sands or serpentine barrens, in soils of low pH and high ion exchange capacity and in iron stone soils. Soils depleted by exhaustive cropping are commonly known to develop Molybdenum deficiency (Dickinson 1946).

Zinc :

Next to nitrogen, Zinc is known to be more generally deficient than the other trace elements in tropical soils. The Californian workers were the first to

recognize the mottle leaf of citrus trees as a deficiency disease which was corrected by application of Zinc salts (Chandler 1937 ; Chapman *et al.* 1937). Skoog (1940) pointed out its role in auxin metabolism of higher plants. Nevertheless little is known about the exact role of Zinc in plant nurition.

High lime content and high soil pH seem to favour Zinc deficiency. Nelson *et al.* (1959) showed a correlation between acid-extractable Zinc and titrable acidity (or alkalinity) in calcareous and non-calcareous soils.

In India, Nair and Mehta (1959) analysed acid-soluble and total Zinc content of 58 typical soils from Gujarat and Saurashtra areas. The acid-soluble Zinc content varied from 0·5 to 6·05 p.p.m. with an average of 3·06 p.p.m. The total Zinc content varied from 20 to 95 p.p.m. with an average of 60 p.p.m. Positive correlation was reported between acid-soluble and total Zinc contents. Significant positive correlation was also obtained between acid-soluble Zinc and organic matter content and a negative correlation between pH and acid-soluble Zinc. Maximal accumulation of acid-soluble Zinc was fouud in surface soils.

Rao (1937) reported a high Zinc content in some soil samples from the west coast of India in the range 300-600 p.p.m. In the citrus soils of Bombay State, Bendale, Narayana and Kibe (1951) reported low values for Zinc content, 0·44 to 0·12 p.p.m. in one set and 7·9 to 17·6 p.p.m. in another set. Biswas and Dakshinamurti (1958) studied the micro-element distribution in soil profiles upto a depth of 8′ and showed an increase in Zinc content in the sub-surface profiles over the surface samples. The range of Zinc distribution was from 24·2 to 44·1 p.p.m.

The role of Aluminum, Arsenic, Barium and Strontium, Beryllium, Cadmium, Cobalt, Chromium, Fluorine, Iodine, Lithium, Rubidium and Caesium, Nickel, Selenium, Titanium and Vanadium in soils has also been studied. They are not generally considered essential to higher plants since their absence from the soil is not known to have any significant effect on normal plant growth.

Aluminum :

Aluminum has been found in the ash of all of plants that have been examined though to different degrees. The percentage of Aluminum in plants is very small though some species accumulate an unusually high amount. Kratzmann (1914) analysed 130 species of plants for their Aluminum content. In *Poa caespitosa* litter in alpine humus soils, 15 to 20% of Aluminum was found (Costin 1954). The grass had higher amounts of sesquioxides than the parent gneissic granite. Webb (1954) recorded accumulation of Aluminum in 69 species of dicotyledons and 4 species of ferns in Australian-New Guinea flora. Although, Aluminum is present in most of the Indian soils no particular work has been done as to its importance as a trace element.

Arsenic :

Arsenic in the form of disodium arsenate was shown to have a beneficial influence at low concentrations on beans, wheat and radish by Stewart (1922) who suggested that the accumulation of Arsenic in the soil from spray might be beneficial rather than injurious to plants. Brenchley (1914) considered Arsenious compounds more toxic to plants than Arsenic compounds. Albert and Paden (1931) believed that the addition of Calcium arsenate to light sandy-loam soils may be expected eventually to interfere seriously with growing of arsenic-sensitive crops as oats, cotton and various grasses.

Barium And Strontium :

In the humid tropics region, Robinson, Edington and Byers (1935) analysed Cuban soils and reported a value of 15 p.p.m. of Barium in surface soils. From the Hawaian islands Ballard (1940) recorded the presence of both Barium and Strontium from surface soils.

Beryllium :

Average Beryllium content of Russian soils was reported to be 10 p.p.m. by Vinogradov (1957). In India Rao (1937) suspected the presence of this trace element in some sugarcane soils. Chamberlain (1959) reported Berryllium content from 0·02 to 6·5 p.p.m. in some East African soils.

Cadmium :

This element occurs in very small amounts in soils and the only information available about the tropics is from some tobacco soils from Sumatra where Roelofsen (1943) detected the presence of this trace element.

Cobalt :

While little is known of the role of cobalt in plant metabolism considerable interest has centred around this trace element on account of its relationship to Vitamin B_{12}. Cobalt is required by animals. Lack of sufficient amount of this element in the soil causes severe Cobalt deficiency in animals which are pastured on such soils. Numerous reports have recently appeared on the Cobalt content of soils not only from the tropics but also the others. The average soil content of this element varies in the range 1-40 p.p.m. Vinogradov (1957) gives a figure of 3 p.p.m. for the Russian soils, while Malyuga has recorded 10 p.p.m. McMurtrey and Robinson (1938) reported a figure of 10·15 p.p.m. for some American soils.

Ahmad and Shariff (1953) analysed a number of productive soils from East Pakistan and reported figures in the range 6-20 p.p.m. Tracer techniques with Co^{60} was used in the study of soils and clays by Banerjee, Brey and Melsted (1953).

Datta and Biswas (1951) determined the Cobalt content of Indian grasses and forage crops and found a sufficient amount of Cobalt and Copper in the young stage decreasing in the older plants.

Iodine :

The interest in Iodine as a trace element for plants has been aroused because of the importance of the element in the prevention of goiter.

The element occurs both in organic and inorganic forms in plants. A number of workers have shown that the quantum of Iodine absorbed by plants is approximately proportional to the available Iodine, though it may not be very explicit on account of soil reactions (McHargue, Young and Calfee 1935; Beaumont and Karns 1932 ; Conner 1931). There have been practically no reports of soil survey work for the detection and evaluation of Iodine in humid tropical soils.

BIBLIOGRAPHY

Ahmad, K. and Sharif, A. H. 1953. Cobalt Status of East Pakistan soils. *Pakistan J. Sci. Research* **5** : 119-20.

Albert, W. B. and Paden, W. R. 1931. Calcium arsenate and unproductiveness in certain soils. *Sci.* **73** : 622.

Anderson, A. J. 1956. Molybdenum deficiencies in legumes in Australia. *Soil Science*, **81** : 173-182.

Anderson, A. J. and Oertel, A. C. 1946. Factors affecting the response of plants to molybdenum. Australia Council Sci. *Ind. Research Bull.* **198** : (pt. 2) : 25-44.

Arnon, D. I. and Stout, P. R. 1939. Molybdenum as an essential element for higher plants. *Plant Physiol.* **14** : 599.

Aso, K. 1907. On the continuous aplication of manganous chloride in rice culture II. *Col. Agr. Imp. Univ. pokyo Bull.* **7** : 449.

Ballard, S. S. 1940. A spectrographic study of the distribution of mineral elements in sugarcane. *Hawai Plant. Rec.* **44** : 183-186.

Banerjee, D. K., Bray, R. H. and Melsted, S. W. 1935. Some aspects of the chemistry of Cobalt in soils. *Soil Sci.* **75** : 421-31.

Beaumont, A. B. and Karns, G. M. 1932. Effect of an iodine fertilizer on iodine content of a food plant. *Sci.* **78** : 567.

Bendale, J. R., Narayana, N. and Kibe, M. M. 1951. Trace element contents of black cotton soils of a few citrus-growing tracts of the Bombay State. *Poona Agric. Coll. Mag.* **42** : 3-10.

Berger, K. C. 1949. Boron in soils and crops. *Advanc. Agron.*, **1** : 321-351.

Biswas, T. D. 1951. Manganese status of some Indian soils. *Indian J. Agric. Sci.* **21** : 97-107.

———— 1953. Distribution of Manganese in Profiles of some Indian soils. *J. Indian Soc. Soil Sci.*, **1** : 21-31.

Brenchley, W. E. 1914. On the action of certain compounds of Zinc, Arsenic and Boron on the growth of plants. *Ann. Bot.* **28** : 283-302.

Brito-Muthunayagam, A. P. and Koshy, M. M. 1952. Soil phosphorus. I Chemical Nature and distribution of Phosphrus in soils of Travancore-Cochin. *Bull. Central Research Inst. Univ. Travancore*, **11** : 63-76.

Chamberlain, G. T. 1959. Trace elements in some East African soils and plants. I. Cobalt, Beryllium, Lead, Nickel and Zinc. *E. Afr. Agric. J.* **25** : 121-126. (E. Afr. Agric. For. Res. Org., Klikuyul)

Chandler, W. H. 1937. Zinc as a nutrient for plant. *Bot. Gaz.* **98** : 625-646.

Chandler, W. V. and Scarseth, G. D. 1941. Iron starvation as affected by over phosphating and sulfur treatment on Hauston and Sumter clay soils. *Jour. Amer. Soc. Agron.* **33** : 93-104.

Chapman, H. D. *et al.* 1937. The production of citrus mottle-leaf in controlled nutrient cultures. *Jour. Agr. Res.* **55** : 365-379.

Conner, W. H. 1931. Study of the iodine content of Florida-grown crops. *Fla. Sta. Ann. Rept.* **45** : 65.

Costin, A. B. 1954. Accumulation of Aluminium in plants. *Australian J. Sci.* **17** : 38.

Datta, N. P. and Datta Biswas N. R. 1951. Trace elements in some Indian Grasses, Forage Crops, Concentates, and Mineral supplements. *Ind. J. Agr. Sci.* **21** : 93-6.

Datta Biswas, N. R. and Dakshinamurthi, C. 1955. Influence of molybdenum on the growth and yield of berseem. *Proc. Nat. Acad. Sci. India*, **24 A** : pt. 5 : 573-81.

——— 1959. Note on the Micro-element distribution in I. A. R. I. Farm Profile. *Ind. J. Agron., Vol. III*, No. **1** : pp. 48-51.

Dennis, R. W. G. 1947. Boron and plant life—Part VI. Developments in agriculture and horticulture, 1943-46. *Ferti. Feed. St. J.*, **33** : 465-470, 493-498, 519-524, 549-555, 575-580, 611-614.

——— 1948. Boron and plant life—Part VI. Development in agriculture and horticulture, 1943-1946. *Ferti. Feed. St. J.*, **34** : 71-77, 101-107, 137-140, 167-168.

Dennis, A. C. and Dennis, R. W. G. 1943. Boron and plant life—Part V. Development in agriculture and horticulture, 1940-1942. *Ferti. Feed. St. J.*, **29** : 119-127, 151-157, 175-185, 199-205, 223-230, 245-252.

Dhawan, C. L. and Dhand, A. D. 1950. The occurrence and significance of trace elements in relation to soil deterioration. II. Boron. *Indian J. Agr. Sci.* **20** : 479-85.

Dickinson, H. R. 1946. The Kinburn pasture plots, Grossy. *Tasmanian J. Agri.* **17** : 173-179.

Eden, T. 1933. The report of the agricultural chemist. *Bull. Tea Res. Inst. Ceylon*, No. **11** : 49.

Gandhi, S. C. and Metha, B. C. 1958. Water-soluble boron contents of the soils of Gujarat and Saurashtra. *J. Indian Soc. Soil Sc.* **6** : 95-101.

Ghani, M. O. and Haque, A. K. M. Fazlul, 1945. Studies on the Boron status of some Bengal soils. *India. J. Agric. Sci.* **15** : 257-262.

Gile, P. L. and Carrero, J. O. 1916. Assimilation of iron by rice from certain nutrient solutions. *J. Agr. Res.*, **7** : 503-528.

Gilbert, F. A. 1952. Copper in Nutrition. *Adv. Agron.* **4** : 147-77.

Guha, M. P. 1952. Boron deficiency and its relation to tuber cracking of potatoes. *Sci. Cult.* **17** : 40-2.

Iyer, R. R. Harihar and Rajagopalan, R. 1936. Determination of Manganese in soils. *J. Indian Inst. Sci.*, **19 A** : 57-66.

Johns Hopkins Press, 1950. Symposium on Copper Metabolism.

Kelley, W. P. 1914. The function of Manganese in plants. *Plant Physio.* **5** : 373.

Koch, D. E. V. 1946. The manganese content of some Ceylon soils. *Trop. Agriculturist*, **102** : 219-223.

Kratzmann, E. 1914. The physiological action of the salts of aluminum upon plants. *Sitzungsber. Akad. Wiss Wien*, **123** : 211-233 ; *Exp. Sta. Rec.* **34** : 525.

Lal, B. M., Sahu, D. and Das, N. B. 1959. Studies on available copper in some Indian soils. *Curr. Sci.* **28** : 494.

McHargue, J. S., Young, D. W. and Calfee, R. K. 1935. The effect of certain fertilizer materials on the iodine content of important foods. *J. Am. Soc. Agron.* **27** : 559-565.

McMurtrey, J. E. and Robinson, W. O. 1938. Neglected soil constituents that affect plant and animal development. *Yearb. U. S. Dep. Agric.* 807-829.

Mulder, E. G. 1954. Molybdenum in relation to growth of higher plants and micro-organisms. *Plant and soil.* **5** : 368-415.

Nair, G. G. K. and Mehta, B. V. 1959. Status of Zinc in soils of Western India. *Soil Sci.* **87** : 155.

Nelson, J. L., Boawn, L. C. and Viets, F. G. Jr. 1959. A method for assessing Zinc status of soils using acid-extractable Zinc and "titratable alkalinity" values. *Soil Sci.* **88** : 275-283.

Nieschlag, 1955. Die Mikrodungungin kartoffelbau. *Kartoffelbaw*, **6** : 4.

Philipson, T. 1953. Boron in plant and soil, with special regard to Swedish agriculture. *Acta. Agric. Scand.*, **3** : 121-242.

Rao, A. L. S. 1937. Studies in the physical and chemical properties of some sugarcane soils. *Proc. Indian Acad. Sci.*, **6B** : 91-97 ; *Curr. Sci.*, **6** : 23 (1937).

Reddy, G. R. and Mehta, B. V. 1958. Availability of molybdenum in Gujarat soils. *Vedya Sci.* **2** (2) : 87-91.

Roelofsen, A. P. 1943. Recent research at the Deli Tobacco Experiment Station, Medan Sumatra. *Emp. J. Exp. Agric.*, **11**, 15-22.

Sankarasubramony, H., Pandalai, K. M. and Menon, K. P. V. 1951. The manganese content of soil and plant tissue in relation to the root and leaf diseases of the coconut palm. *Indian Cocon. J.*, **4** : 165-170.

Satyanarayan, Y. 1958. Water soluble boron in some desert soils of India. *J. Indian Soc. Soil. Sci. 1958*, **6** : 223-26.

Skoog, G. 1940. Relationship between Zinc and auxin in the growth of higher plants. *Amer. Jour. Bot.* **27** : 939-951.

Stewart, J. 1923. Some relations of arsenic to plant growth. I and II. *Soil Sci.* **14** : 111-127.

Stocklasa, J. 1929. Uben den Einfluss des Jodions auf das Wachstum and die zellvermehrung der Halophyten. *Biochem. Z.*, **211** : 213-228 ; *Biol. Abst.* **5** : 1616.

Stout, P. R. *et al.* 1951. Molybdenum nutrition of crop plants. 1. *Plant and soil* **3** : 51-87.

Thorne, D. W. and Wallace, A. 1944. Some factors affecting chlorosis on high-lime soils. 1. Ferrous and Ferric iron. *Soil Sci.* **57** : 299-312.

Vinogradov, A. P. 1940. Copper content of different soils. On the question of the so-called Urbarmachuncskrankheit of crops. *C. R. Acad. Sci. U. S. S. R.* **27** : 1002.

——— 1957. Geochemistry of dispersed elements in soils. *2nd Ed. U. S. S. R. Acad. Sci. Moscow.*

Webb, L. J. 1954. Aluminum accumulation in the Australian-New Guinea Flora. *Australian J. Botany*, **2** : 176-96.

Wilson R. D. and Waring E. J. 1948. Some observations and experiments concerning the role of Molybdenum in the nutrition of Cauliflower plant. *Jour. Austral. Inst. Agr. Sci.*, **14** : 141-145.

PROBLEMS OF ADAPTATION AMONG HERBACEOUS PLANTS OF THE TROPICS

By

R. MISRA

Benares Hindu University, Varanasi

Any structural, physiological or developmental feature of a plant fitting it in a given environment for survival is an adaptation. A plant may be sufficiently plastic to exhibit adaptations in response to temporal and spatial changes in the environment during its life history. The ecological coverage of such a biotype is likely to be extensive with a number of ecads or ecophenes as seen in many of the tropical marsh plants extending from dry to wet situations or in seasonal forms of a herb like *Xanthium strumarium* L. A similar and perhaps more extensive habitat coverage is provided by a number of biotypes arising within the species ecotypically. Such differentiation is naturally achieved genetically through successive generations. Some examples of ecotypes will also be given. It follows then that a species of very narrow ecological distribution is not equipped biologically to produce either ecads or ecotypes. The recognition of these forms may, however, be difficult should the adaptations within a population be only physiological.

The purpose of this paper is not to discuss the significance of the above statements in the study of speciation but to give an understanding of a variety of adaptations as obtained in some plants of the tropics.

Tropical environments as compared with the temperate have higher temperature with smaller seasonal and diurnal fluctuations, short photoperiod and soils developing under laterisation and/or calcification with no peat. However, accumulation of deep peat has been recently reported in Borneo and Sarawak which might be due to low bacterial activity for some reason. Higher altitudes in the tropics may present temperate conditions but they too differ in the matter of low air pressure and short photoperiods together with their concomitant effects.

It is pertinent to draw attention to the way ecological life-history is studied in order to reveal the adaptation in the background of a tropical environment. A study of plant from the seed to the seed stage against critical factors of the habitat must be followed both in the field and under cultivation. The study is supported by much experimental and analytical work in the laboratory with regard to structural, physiological and developmental features of the plant. The persuit is bound to reveal significant adaptations as shown in the following example :—

Peristrophe bicalyculata Nees. is distributed in ruderal shady places rich in soil nitrogen or in the open on sandy and nitrogen poor soil. Culture experiments and soil and ash analyses reveal that both germination of seeds and growth of the plant are synchronised with the physiological adaptation of nitrogen absorption and assimilation as affected by light. Some similar findings have been reported for *Scilla* in England by Rutter and Blackman.

Euphorbia hirta L. roots adapt to erosion by peculiar habit of one sided growth. The mode of branching of roots following silting in *Ricinus communis* L. and in *Scoparia dulcis* L. following inundation are good examples of adaptation as shown by Ambasht (1961). Ramam (1960) has demonstrated defoliation effects on the root habit of *Dichanthium annulatum* Stapf.

A number of ecads and ecotypes with definite adaptations have been revealed by Ramakrisnan (1960) in *Euphorbia hirta* L., *Echinocloa colonum* Link., *Setaria glauca* Beauv. and *Euphorbia thymifolia* L.

The erect and tall ecotype of *Euphorbia hirta* L. is adapted to moist and shady habitats in contrast to the prostrate and compact ecotype of dry and exposed situations. The latter produces a very compact ecad which grows on foot paths. Two ecotypes are shown in *Echinocloa colonum* Link. in as much as the tall form is adapted to aquatic situations and the dwarf one to drier areas which incidently happens to be calcicolous also. Ecads and ecotypes in response to moisture conditions of the habitat also develop in *Setaria glauca* Beauv.

Adaptational features in *Euphorbia thymifolia* L. appear to be more complex. The green ecotype is an obligate clacifuge and the red one is a facultative calcicole. It is interesting to find that the green ecotype can absorb more of calcium from calcium poor soil whereas the red calcicole can absorb lesser amounts with increasing lime in the substratum in contrast to the behaviour of another calcicole *viz.* *Lindenbergia polyantha* Royle examined by Misra. Breeding work in the plant has indicated that colour incidence and physiological behaviour of the plant are conrolled by polygenes of duplicate factor type so that according to the degree of anthocyanin pigmentation five forms are produced in F_2 in the ratio of 1 : 4 : 6 : 4 : 1 with decreasing pink of which the first two are the facultative calcicoles and the remaining three are the obligate calcifuges thus accounting for the two ecotypes. It is clear that in nature the two ecotypes interbreed with a high degree of fertility on lime poor soils.

ORGANIC MATTER AND PHOSPHATES IN LAND FERTILITY INCREASE

By

N. R. DHAR

Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.

Very appropriately nitrogen has been designated as the "growth element" in plant and animal nutrition. It is present in chlorophyll, proteins and many other compounds essential to plant and animal life. An adequate supply of nitrogen is absolutely essential for growth and reproduction in both plants and animals. Along with carbon, hydrogen, oxygen and frequently with phosphorus and sulphur, nitrogen forms a vital component of every living cell and a necessary part of plant and animal tissues. Without nitrogen life is an impossibility.

Except for leguminous plants free nitrogen is no plant food. Nitrogen must be combined with other elements, that is, it has to be fixed before it can serve as a fertilizer or a nitrating agent in the manufacture of dyes, drugs and explosives. Because of the great value of nitrogenous compounds in agriculture and industry, the nitrogen fixation industry in many countries is as important as the coal or steel industry.

It is generally believed that the cultivation of food crops was begun by man 10,000 to 12,000 years ago. The value of animal manures was discovered when nomadic man with his animals first settled down and began agriculture and used the dung of his animals for fertilizing land.

It is of interest to record that from ancient times two view points have been advanced regarding the materials useful in plant nutrition. Bernard Palissy (1510-1589), Bacon (1561-1626), Glauber (1604-1668), Boyle (1627-1691) and especially Liebig (1803-1873) were supporters of the theory, first emphasised by Paracelsus (1493-1541) that salts were the true nutrients of plants. On the otherhand, Home (1719-1813), Wallerius (1709-1785), Thaer (1752-1828), N. T. de Saussure (1767-1845), Davy (1778-1829), De Candolle (1778-1841), Berzelius (1779-1848), Mulder (1802-1884) and others, were advocates of the Aristotlean doctrine of plant nutrition by soil organic matter.

The science of crop fertilizing began when in 1804 N. T. de Saussure analysed plant ashes and reported that the chemicals present in the ashes were derived from the soil. This work of de Saussure was quantitatively verified and extended by J. B. D. Boussingault (1802-1887) in his experimental farm in Alsace in 1830. Baron Justus von Liebig's great credit is his marked emphasis on the necessity of providing plants with phosphates and potash, but he failed to grasp the essential value of nitrogenous compounds in crop production and this was proved in Rothamsted by Lawes, Gilbert and Pugh in 1857.

Bones are known to have been used for fertilizing in England in the 17th century to the extent of even 1 ton per acre. In this connection Liebig wrote as follows: "England is robbing all other countries of the condition of their fertility. Already in her eagerness for bones she has turned up the battle fields of Leipzig, of Waterloo and of the Crimea ; already from the Catacombs of Sicily she has carried away the skeletons of many successive generations."

Guano, the excrement of sea fowl, turtle and seal are found in many parts of the world and the largest deposits occur in Peru. It has been stated that guano was used in Europe in cultivation since the 12th century. Bones and guano are rich in calcium phosphates and nitrogenous compounds.

Physicists have calculated that approximately 100 million tons of nitrogen are converted into nitric acid by electric discharge in the earth's atmosphere annually but only 6 to 10 million tons of nitrogen fall on the 5,000 million acres of land under cultivation in the world.

In a recent study on "Observations on the Planned Provision of Nitrogen Fertilizer", Professor Tinbergen and others concluded that the consumption of nitrogen per acre of land is directly proportional to the population density of the country. Moreover, in a recent publication (1957) on "Industrial uses of nitrogen" by the European Productivity Agency of the O. E. E. C. the following lines occur : "As world nitrogen production is out stripping the expansion of demand for traditional purposes (particularly for nitrogenous fertilizer) all producers are looking round for new outlets". Hence the amounts of chemical nitrogen used are still inadequate as the quantities of fertilizer nitrogen applied per acre in lbs per year in 1937 were as follows : Belgium (28·5), Holland (24·8), Germany (15·6), Denmark (10·3), Norway (6·0), Sweden (5·24), Italy (4·3), France (4·0), U. K. (2·5), U. S. A. (1·36) Poland (0·73) and Hungary (0·15).

At present the consumption of nitrogenous fertilizers has increased in many countries and this is evident from the following figures indicating the nitrogen used in kilograms per hectare of land under cultivation in 1956-57 : Australia (11·5) Belgium (52·5), Denmark (29·6), France (14·4), West Germany (35·1), Greece (12·1), Iceland (85·9), Ireland (3·2), Italy (14·7), Luxembourg (28·0), Netherlands (79·0), Norway (38·1), Portugal (10·5), Sweden (22·4), Switzerland (10·1), Turkey (0·4), U. K. (23·5), Spain (9·5), U. S. A. (4·2).

It has been reported that there is a shortage of chemical fertilizers in the U. S. S. R. although there are 71 plants producing fertilizers. The following figures show the nitrogen utilization in kilograms per hectare of land in some East-European and Eastern countries : East Germany (31·6), Poland (10), Czechoslovakia (5), Japan 109·6), Taiwan (86·7), Republic of Korea (54·1), Ceylon (18·4), Philippines (5·6), China (2·3), Indonesia (2), India (1), Pakistan (0·3).

NATURAL PROCESS OF RECUPERATION OF NITROGEN DEFICIT BY FIXATION OF ATMOSPHERIC NITROGEN IN OXIDATION OF ORGANIC MATTER IN SOILS

From our researches carried out on the problem of atmospheric nitrogen fixation in soils by the addition of various organic compounds for over 30 years, we have come to the conclusion that these compounds not only improve the physical properties of soils, add colloids to soils and improve the tilth, crumb formation and water retention capacity of the soil but the organic substances undergo slow oxidation in the soil and liberate energy, which is utilized in fixing atmospheric nitrogen and enrich the soil from the nitrogen view point. Moreover, the carbohydrates in the soil preserve the nitrogenous compounds present in the soil or added to it just as carbohydrates and fats act as protein sparers in the animal body. Some of our recent experimental results are recorded in the following table using a Swedish clay soil collected from the fields of the Royal College of Agriculture, Uppsala 7. The soil contained 0·147 per cent total nitrogen, 1·207 per cent organic carbon, 1·19 per cent CaO, 3·114 per cent MgO, 1·2 per cent K_2O and 0·225 per cent P_2O_5 of which 0·083 per cent is available by 1 per cent citric acid extraction.

The following results were obtained recently in dishes by mixing organic matter with soil and exposing one set to artificial light for eight hours daily and another set covered with black cloth to exclude light. The moisture content was maintained at 20-25 per cent by adding distilled water every alternate day.

TABLE 1

Fixation of atmospheric nitrogen in Swedish soils

	Period of exposure (days)	Organic carbon (%)	Total nitrogen (%)	Carbon oxidized (%)	Increase in nitrogen (%)	Efficiency : N in mg per gm of C oxidized
		Swedish soil + sucrose				
Light	0	2·3568	0·1470	. .	. .	. .
	150	1·4833	0·1656	0·8735	0·0186	21·3
	300	1·2723	0·1682	1·0845	0·0262	28·4
Dark	0	2·3568	0·1470	. .	. .	. .
	150	1·7247	0·1554	0·6321	0·0084	13·3
	300	1·5036	0·1598	0·8532	0·0128	15·0
		Swedish soil + 0·25% P_2O_5 as Gafsa rock phosphate + sucrose				
Light	0	2·3568	0·1470	. .	. .	. .
	150	1·4123	0·1862	0·9436	0·0392	41·5
	300	1·1518	0·1992	1·2050	0·0522	43·4
Dark	0	2·3568	0·1470	. .	. .	. .
	150	1·6787	0·1608	0·6781	0·0138	20·3
	300	1·4612	0·1658	0·8956	0·0188	21·0

The experimental results show that organic substances like sucrose, straw, cow dung, water hyacinth, lucerne etc. undergo slow oxidation in air when mixed with soil even in the dark as the amount of carbonaceous compounds decrease with lapse of time. In these slow oxidations energy is liberated and this energy is utilized in fixing the nitrogen of the air on the soil surface forming ammonia, amino-acids and other nitrogenous compounds. Thus with the decrease in the quantities of the carbonaceous compounds, there is increase of total nitrogen in all these experiments. When these systems are illuminated by sunlight or artificial light, the light is absorbed by the systems and the amount of nitrogen fixed in presence of light is much greater than that obtained in the dark. In all these experiments the numbers of Azotobacter, total bacteria and fungi are always much smaller in presence of light, which is harmful to micro-organisms, than in the dark, although the nitrogen fixed per gram of the carbon of the energy material oxidized in light is much greater than in the dark. In presence of calcium phosphates, the nitrogen fixation is greatly enhanced.

Dung has been used as a manure from time immemorial. Our experiments show that it not only supplied the plant nutrients it contains but it also fixes atmospheric nitrogen and thus markedly improves the nitrogen content of land all over the world. It has been stated that 14,000 million tons of manure are produced in the world and when ploughed in not only supplies 7 or 8 million tons of nitrogen the manure contains but it can also fix the same amount of nitrogen of the air and thus enriches the soil considerably.

In our experiments with sucrose and other soluble carbohydrates there is marked increase of ammonical nitrogen as well as total nitrogen in a short time but with cellulosic materials like straw, the liberation of ammonia from the fixation of atmospheric nitrogen takes longer time. Consequently a time interval of 3 to 6

months is needed between the incorporation of straw or materials rich in cellulose and lignin in the soil and the sowing of the crop depending chiefly on the soil temperature. In this process basic slag being alkaline and rich in oxidizing catalysts helps in the partial oxidation of the organic substance and the liberation of ammonia and formation of nitrate.

TABLE 2

Fixation of nitrogen in Allahabad soils

	Period of exposure (days)	Organic carbon (%)	Total nitrogen (%)	Carbon oxidised (%)	Nitrogen fixed (lb/acre)	Efficiency
			Allahabad soil + wheat straw			
Light	0	0·7356	0·0492	. .	. .	. .
	90	0·5358	0·0533	0·1998	. .	20·8
	150	0·4762	0·0544	0·2594	. .	20·6
	180	0·4365	0·0553	0·2991	117·6	20·6
Dark	0	0·7356	0·0492	. .	. .	. .
	90	0·5866	0·0507	0·1490	. .	10·6
	150	0·5417	0·0511	0·1939	43·7	10·1
	180	0·5241	0·0513	0·2115	. .	10·2
			Allahabad soil + wheat straw + 0·1% P_2O_5 as $Ca_3(PO_4)_2$			
Light	0	0·7356	0·0492	. .	. .	. .
	90	0·4924	0·0566	0·2432	. .	30·9
	150	0·4181	0·0588	0·3175	215·2	30·3
	180	0·3740	0·0602	0·3619	. .	30·6
Dark	0	0·7356	0·0492	. .	. .	. .
	90	0·5513	0·0522	0·1843	. .	16·3
	150	0·4851	0·0532	0·2505	90·0	16·0
	180	0·4652	0·0534	0·2704	. .	15·8

FIXATION OF NITROGEN BY WATER HYACINTH

It is well known that water hyacinth *Eichhornia crassipes* which grows abundantly in India and other warm countries is a great menace. But we have observed that this material containing 2·86% CaO, 1% MgO, 5·32% K_2O, 0·676% P_2O_5, 41·9% C and 2·39% N when mixed with soil can fix atmospheric nitrogen more in light than in the dark and the nitrogen fixation is increased by adding basic slag (Thomas slag). Water hyacinth mixed with basic slag is being used as a manure in different parts of India and in Florida in rice production.

The nitrogen fixation is found to be more accelerated by di- and tri- calcium phosphates than monocalcium phosphates. Ferric and aluminium phosphate show a small increase of nitrogen. In all these experiments we have observed that the numbers of Azotobacter, total bacteria and fungi are much smaller in the vessel receiving light than in that kept in the dark, although the nitrogen fixation is much greater in light than in the dark. This clearly proves the influence of light in increasing the nitrogen content of soils and their fertility by light absorption.

TABLE 3

Fixation of atmospheric nitrogen in Allahabad soil

	Period of exposure (days)	Organic carbon (%)	Total nitrogen (%)	Carbon oxidized (%)	Nitrogen increase (%)	Efficiency
			Allahabad soil + cowdung			
Light	0	1·7262	0·0942	. .	. .	. .
	60	1·5077	0·0990	0·2185	0·0048	22·4
	120	1·3411	0·1044	0·3851	0·0102	26·5
	180	1·2120	0·1083	0·5142	0·0141	27·5
Dark	0	1·7262	0·0942	. .	. .	. .
	60	1·5230	0·0970	0·2032	0·0028	13·8
	120	1·4248	0·0988	0·3014	0·0046	15·3
	180	1·2647	0·1015	0·4615	0·0073	16·0
			Allahabad soil + Cowdung + 0·25% P_2O_5 as Tata basic slag			
Light	0	1·7125	0·0925	. .	. .	. .
	60	1·0373	0·1208	0·6752	0·0283	41·9
	120	0·9489	0·1249	0·7641	0·0321	42·0
	180	0·9232	0·1279	0·7893	0·0354	44·8
Dark	0	1·7125	0·0925	. .	. .	. .
	60	1·3713	0·0984	0·3412	0·0059	17·5
	120	1·2974	0·1010	0·4151	0·0085	20·3
	180	1·2277	0·0310	0·4848	0·0105	21·7

CALCIUM PHOSPHATES INCREASE NITROGEN IN SOIL

In enriching fields by growing legumes, it has been frequently stated that under normal conditions 112 pounds of nitrogen are added per acre but usually the amount varies from 40 to 60 pounds per acre. In our experiments with straw recorded in the table 2, 0·5 per cent carbon was used as straw and in presence of light and calcium phosphate, a nitrogen fixation of 215 lbs per acre was observed. Hence by ploughing in straw mixed with calcium phosphates like basic slag, soft phosphate rocks, nitrogen addition of the same order as in legumes or more can be readily obtained in cultivated lands of the world.

In Allahabad, by mixing municipal wastes with or without basic slag to a field soil containing 0·5% organic carbon and 0·04% total nitrogen, the results obtained after one year are given in table 5.

These results show that in Allahabad where the average surface soil temperature is 26°C, organic matter incorporation increases soil fertility markedly and is further enhanced by adding basic slag as well and bumper crops are produced. Similar results are obtained by mixtures of animal dung or wheat straw and North African soft phosphate rock and basic slag. Our experiments and those of others show that phosphate rich soils are rich in nitrogen and are very fertile and their C/N ratio is usually smaller than 10.

Karraker observed increased nitrogen fixation by a mixture of manure and phosphate (note reference).

It is well known that in Rothamsted, England, by ploughing in 14 tons of farmyard manure containing 200 pounds of nitrogen per acre and growing wheat every year since 1843 when the soil total nitrogen was 0·122 per cent, the total nitrogen has gone up at present to 0·274 per cent. Whilst by ploughing in 86 or 129 pounds of nitrogen as ammonium sulphate or sodium nitrate and growing wheat every year there has been a soil deterioration shown by decrease of total nitrogen. Similar results showing fertility improvement by dung and not by ammonium sulphate or a nitrate were recorded in the U.S.A., Denmark and other countries.

Botanists have estimated that approximately 13,750 million tons of organic carbon are added per year to the earth by photosynthesis as cellulosic substances. Assuming that only 40% of the carbon introduced by photosynthesis in the world soils is oxidized per year and there is a fixation of only 20 milligrams of nitrogen in sunlight per gram of carbon oxidized, the amount of nitrogen fixed on the surface of the world soils would be approximately 110 million tons per year, half of which is caused by sunlight absorption. Hence this nitrogen fixation seems to be the chief source of soil nitrogen and crop production in the world.

NITROGN IN CROP PRODUCTION

It has been frequently stated that nitrogen is the key element in crop production. This is evident in the following table which shows the yield in different countries expected by an application of 1 kilogram of plant nutrient :

Estimated average increase in yields in kilograms in tillage and grasslands from 1 KG of plant nutrient.

Country	Crops in Rotation			Permanent Pastures		
	N	P	K	N	P	K
Norway	9	3	5	11	6	4
Sweden	14	11	7	14	11	7
Denmark	18	4	2	12	5	3
U. K.	16	5	5	. .	. .	. .
Ireland	20	8	8	. .	. .	. .
Netherlands	19	6	3	10	6	4
France	19	5	2·1	. .	. .	. .
Germany	19	8	4	9	10	5
Switzerland	18	8	4	9	10	5
Greece	15	5	3	. .	. .	. .
Italy	11	3	. .	12	4	3
Average	16	5	4	11	7	4

It seems that there is a close relationship between climatic conditions and the effect of nitrogen. The lowest nitrogen influence has been observed in Norway, Sweden Italy and Greece. Lack of water has been very often a factor which restricted the production. The influence of phosphate and potash on crop yield is much lower than that of N.

The United Nations Korean Reconstruction Agency in their report "Agriculture, Forestry and Fisheries in South Korea", New York, Columbia University Press, 1954, pages 99–102, have stated that 1 kg. of N as ammonium sulphate can produce 12–14 kilograms of brown rice and 14–28 kgs. of rough barley in South Korea. Similarly, 1 kg of P_2O_5 from superphosphate can yield 14 to 18 kilograms of brown rice in some places, whilst in other places 4 to 5 kilograms of brown rice are produced per kg of P_2O_5.

POSSIBILITIES OF INCREASED USE OF FERTILIZERS OVERESTIMATED

In U. S. A. Baum, Heady, Pesek and Hildreth, (Iowa State College Press, 1957, page 139) observed large increases in yield due to applications of nitrogen were obtained on both soil types. The increase was larger, on the average, for the Norfolk than for the Posrtsmouth soil. *No increase from applications of nitrogen was obtained for rates above 125 lbs per acre. There was some evidence that 188 and 250 lbs rates of nitrogen depressed the yield slightly below that obtained with 125 lbs rate at locations 508, 553 and 558.*

NITROGEN REQUIREMENTS OF CROPS IN THE WORLD AND SOME COUNTRIES

Excluding the U. S. S. R., the world production of cereals and millets in 1956 was as follows :

	In million tons
Wheat . .	159
Rye . .	20
Barley . .	76
Oats . .	52
Maize . .	165
Millet and Sorghum . .	71
Rice, paddy . .	216
	759

This production has appreciably increased in 1956 because it was 627 million tons between 1948–1952.

The cereal production in the U. S. S. R. is of the order of 161 million tons. Consequently, the world cereal and millet production can be roughly taken to be 1,000 million tons at present. Other food materials like pulses, potatoes, sugar etc. are produced to the extent of 700 million tons. Consequently, 1,700 divided by 16, *i.e.* approximately 100 million tons of nitrogen are necessary for producing the world food materials. But the chemical industry is supplying only 7 million tons of nitrogen and legumes 5 million tons.

Nearly 150 million tons of cereals are produced in the U. S. A. at present and 85 million tons of other food materials. Hence, the nitrogen requirement of the food materials produced in the U. S. A. is of the order of 15 million tons. But 1·5—2 million tons of chemical N, 2 million tons of legume N and perhaps 1 million ton of farmyard manure nitrogen are applied to the 520 million acres of agricultural land in the U. S. A.

In the U. S. S. R. the total N requirement for producing the cereals and other food is of the order of 14–16 million tons per year. In recent years Soviet farm production has increased due mainly to the increased acerage In 1958 in the U. S. S. R. 12·4 million tons of mineral fertilizers were produced. But nitrogen formed approximately 1 million ton. Russia is planning to triple her output of mineral fertilizers in the next 5 years and produce 70% more crops. By 1965, 35 million tons fo mineral fertilizers are expected. But the N content of the mineral fertilizer would be of the order of 3 million tons. However, the amount of nitrogen necessary for the increased crop production in the U. S. S. R. is likely to be 20 million tons.

In India the cereal and millet production in million tons in 1956 was as follows

Rice 31·6 ; Millet 18·4 ; Sorghum 16·7 ; wheat 12·3 ; maize 3·7 ; barley 3·4.

This makes a total of 86·1 million tons per annum and, hence, the N requirement is of the order of 6 to 7 million tons. On the other hand, the expected N productions in million tons in 1960–61 are :

Sindri 0·1189 ; South Arcot (Neveyli) 0·0203 ; Nangal 0·0406 ; Rourkela 0·0711 and private firms 0·0366, making a total of 0·2875 million tons. But, in 1956, 0·155 million tons of N were used in crop production in India.

It is of interest to note that Japan expects to produce 1·3 million tons of N as early as possible. Moreover, at present, there is an enormous demand for nitrogenous fertilizers in China and the application of chemical fertilizers is going up.

But China is also the largest user of organic materials and utilises 70% of the 200 million tons of available night soil. 50% of agricultural land received night soil and stable manure, 20 to 30% compost and 10 to 15% green manure. It has been estimated that the Chinese utilize over a million ton of N, 1/2 million ton of K and 1/4 million ton of P as organics per year. Their crop production is higher than in many countries although the lands have been cultivated for thousands of years. This is possible because in China the quantities of plant nutrients introduced in the soil along with humus in the form of organics exceed the amounts applied as commercial fertilizers.

Similarly in Japan, along with large doses of artificials, a great amount of humus is produced by organic manures and utilized in crop productson. The amounts of plant food normally recommended in Japan are :

Organic Matter	. .	3,711 to 4,640 lbs/acre
N	. .	105 to 131 „ „
P	. .	35 to 44 „ „
K	. .	56 to 70 „ „

Rice is produced at the rate of 80 bushels per acre and the manuring is as follows :

		Pounds per acre			
		N	P	K	
Manure compost	. .	5291	26·4	5·9	27·1
Green manure, soybeans	. .	3306	19·2	1·1	19·6
Soybean cake	. .	397	27·8	1·7	16·4
Superphosphate	. .	198	. .	12·8	. .

For growing barley the following plant nutrients are applied :

Manure compost	6613	33	7·4	33·8
Rape seed cake	330	16·7	2·8	3·5
Night soil	4630	26·4	2·6	10·2
Superphosphate	132	. .	9·9	. .
Total for the year	20897	149·5	44·2	100·6

It appears that in intensive cultivation a large dose of organic matter is absolutely necessary for efficient crop production with increasing amounts of chemical fertilizers. This is being realised all over the world.

If we assume that only 50% of the nitrogenous fertilizer applied in various countries used in cereal production and divide the amounts of cereal production by the quantities of nitrogenous fertilizer utilized for growing the cereals, we obtain some interesting figures. They show that in countries where large amounts of nitrogenous fertilizers are applied per unit area, small values are obtained as the ratio of creal : N. The ratios obtained are recorded in increasing order in various countries Netherlands (17), Norway (24), Belgium (38), East Germany (48), Ceylon (49), West Germany (50), U. K., Taiwan (54), Finland (56), Japan (58), Luxembourg (60), Portugal (64),,Sweden (66), Greece (72), Denmark (77), Switerland (80), Bulgaria (84), Egypt (90), Spain (92), France (94), Austria (100), Italy (102), U. S. A. (140), Poland (158), China (168), Ireland, Yugoslavia (176), U. S. S. R. (214) PhilipPines (380), Hungary (424), Czechoslovakia (520), India (1934), Pakistan (1205), Turkey (3800) and Thailand (5600). On the other hand, the decreasing amounts of commercial nitrogen used per hectare of land in Kg under cultivation in various countries are as follows : Taiwan (96·8), Japan (92), Netherlands (86·4), Belgium (55·1) Norway (48·6), Egypt (46·5), West Germany (39·5), East Germany,(36·4), Denmark (13·3), Luxembourg (28·3), Sweden (20), Bulgaria 18), U. K. (17·3) Finland (15·3), Ceylon (15), Italy (13·2), France (13), Portugal 9·5, Austria (9), Poland (8), Greece (6·3), Spain (6·1), U. S. A. (4·8), Philippines (4·3), Yugoslavia and Switzerland (4·2) Hungary (3·4), U. S. S. R. (3·3), Ireland (3), Czechoslovakia (2·8), Pakistan (1·3), India (1), China, Thailand (0·4), Turkey (0·12).

It appears that in countries not using large doses of commercial fertilizers the nitrogen response to cereals is very marked and that the law of diminishing return, which is often neglected in modern agriculture by applying heavy doses of commercial fertilizers, is in actual operation in countries like Netherlands, Belgium, Norway etc. But in countries like Japan, China, Taiwan where a lot of composts, plant and animal wastes are utilized along with commercial fertilizers, better crop yields per unit of nitrogen applied are still obtained. Several experimental stations in the U. S. A. have found that yields of wheat and corn are increased by producing greater amounts of organic matter through rotations.

It seems that at least 250 million tons of available N are necessary for the food, fibre and fodder production of the world. But only 3% of it comes from artificials, 2% from legume N and 2–3% from precipitation, and about 2% from farmyard manure, but the rest comes from the soil, the nitrogen of which appears to have been derived from the thermal and photochemical oxidation of carbohydrates photosynthesised. Hence, carbohydrate manuring aided by different calcium phosphates must be well organised all over the world to supply 90% of the nitrogen need of crops.

FORESTRY AND SOIL CONSERVATION IN MAHARASHTRA STATE

By

D. V. KHISTY

Conservator of Forests, Poona Circle, Poona

We all know that the trees are not the only constituent of forests. Each forest stand is associated with shrubs, herbaceous plants, mosses, lichens, fungi, bacteria, protozoa, worms, insects, birds and other animals. Their existence depends on the food furnished by their associates and their occurrence, therefore, is not purely accidental. For this reason, forests can always be referred to as : "Association of mutually related plants and animals which are in a state of biological equilibrium". The word 'biocenos' is used for describing this association. The surface soil in a natural forest is usually covered with leaves and twigs and is protected from erosion. It suffers little so long as this natural protection remains undisturbed. Once this natural protection and the equilibrium are disturbed by Man's activity, it may cause grave consequences leading to subsequent devastation of extensive forest areas. Such devastation naturally leads to the removal of forest cover and once this cover is removed, the soil is laid open to the forces of wind, water and rain, leading to wash off of the soil—a phenomenon scientifically termed as 'Erosion'.

Erosion, therefore, is the removal of soil material by air or water in motion. Erosion can be divided into two categories; *viz.* (1) Geological erosion, and (2) Man induced erosion.

Soil formed by the geological erosion in the ages past was held in place in nature by forests and, as such, in the earlier ages there was no problem of erosion. With the introduction of cultivation and its development, forest litter and the rootlets decayed and disappeared from the soil, the natural equilibrium was disturbed and with this went the last of perfect protection that Nature had provided so well over long years. As more and more of the absorptive surface soil was lost, erosion became easier and easier until finally owing to keen competition of the more easily cultivable lands thousands of acres of hilly lands have been abandoned.

When erosion devastated very large part of the globe, Man realised its dangers and started looking for methods to halt this process of accelerated erosion induced by his own actions. He found that to conserve soil, which simply is a matter of using land as it should be used, it was necessary to make a close study of the soil in relation to its plant bearing capacity. Experience taught Man that the growth and production of forests cannot be understood without the full knowledge of soils. Just as truly, comprehension of forest soil suitability or productivity cannot be acquired without understanding of the biological nature of forest cover, its sociological structure and the complex relationship that exists between the trees and their environment.

Proper use of land is governed by certain physical factors. When the land is used without regard to these factors, process of soil wash off begins. Some lands are too steep to be farmed, some soils are too erodable to be cultivated ; some regions are climatically unsuited for intensive cultivation, and so on. Factors of economic and social character also influence the use of land. Economic end is the powerful factor in determining how land should be used and this factor usually out-

weighs less urgent consideration of conservation, because the man who farms the land must make a living and his is, therefore, the most realistic and economic concern. Soil conservation, therefore, includes not only dealing with soil erosion and the related physical phenomena but it also deals with the complex economic and social considerations that affect land use.

FORESTRY AND SOIL CONSERVATION IN MAHARASHTRA STATE

The State of Maharashtra forms a major part of peninsular India with the sea-coast on its Western side. It lies between 22·1 and 16·4 degrees north latitude and 72·6 and 80·9 degrees east longitude. It has a total area of 1,18,721 Square miles which is a little more than 10 per cent of the area of the Indian Union. The total forest area in the State is 26,000·04 Square miles or 22·4 per cent of the total land area of the State as against the required optimum of 33·1/3 per cent. Even this small percentage of forest is not evenly distributed. Large valuable tracts of forests like those situated in Melghat in Amraoti District, Allapalli and Ahiri forests of Chanda District are far away from centres of population and industries. On the other hand where the need for forests is keenly felt, that is in the vicinity of centres of population and indutsries, forests occur in small bits.

The physical features of Maharashtra present an interesting phenomenon. The altitude varies from practically sea-level to the highest mountain—Mount Kalsubai with an elevation of 5,600 feet.

There is a considerable variation in the rainfall among the different parts of the State. There is heavy rainfall over the Western Ghats and the coastal ract of Thana, Kolaba, Ratnagiri Districts. The rainfall varies from over 150 inches on Ghatmatha to about 80 inches. The major portion of the State lies in the rain-shadow of the Western Ghats with the rainfall average around 25 inches to 30 inches and in some areas even less than 20 inches. The tempetature is more or less equable along the western coast where it varies from 63 F to 92°F. In the rest of the inland areas the temperature range is wider and it goes up right from 60 F to 118°F.

The underlying rock generally belongs to the great volcanic formation known in Geology as the 'Deccan Traps'. A very remarkable character of the lavas of the Deccan Traps is their persistent horizontality throughout their wide area.

CLASSIFICATION OF FORESTS

Different categories of ownership of Forest areas are as under :

Ownership		*Area in Square miles*
1. Forest Department	. .	22,028·01
2. Revenue Department	. .	2,550·64
3. Corporate Bodies	. .	4·09
4. Private individuals	. .	1,417·30
	Total	26,000·04

FOREST TYPES

Forests can be classified into the following broad types :

DRY TROPICAL FORESTS : TROPICAL THORN

These forests are generally found in the rainfall zone of 10″ to 30″. This type extends over about 3,000 Sq. miles. These forests yield only grass, firewood and small timber useful for local consumption only. The principal species growing are : Acacia catechu, Acacia leucophloea, Zizyphus jujuba, Acacia arabica, Butea frondosa, Bauhinia racemosa, Diospyros melanxylon. Santalam album also occurs sparsely distributed in places.

TROPICAL DRY DECIDUOUS : DRY (MIXED) DECIDUOUS

This type of forest is generally distributed in the rainfall zone of 30″ to 60″. This comprises about 12,000 Sq. miles of area. The most important species is *teak* which grows only to medium size. Other associates are Terminalia tomentosa, Anogeissus latifolia, Lagerstroemia parviflora, Lannea grandis, Acacia catechu, Bassia latifolia, Boswellia serrata and Dendrocalamus strictus. The trees grow only to medium sizes in this type.

TROPICAL MOIST (MIXED) DECIDUOUS

This type is generally distributed in the rainfall zone of 60″ to 120″. It occupies about 7,500 square miles. The most important species of this tract is *teak* which can grow to large sizes. The principal associates are Dalbergia latifolia, Terminalia tomentosa, Adina cordifolia, Stephygyne parvifolia, Salmalia malabarica, Lagerstroemia lanceolata, Terminalia paniculata, Semicarpus anacardium and Acacia catechu, Terminalia belerica, Grewia tiliaefolia, Stereospermum chelenoides. Both Dendrocalamus strictus and Bambusa arundinacea occur in this zone. This type forms the main source of commercial timber in the State.

TROPICAL SEMI-EVERGREEN AND EVERGREEN

These are mainly confined to the crests and spurs of the Western Ghats comprising an area of about 300 Sq. miles. They occur in the rainfall zone of over 120″. The principal species are Eugenia jambolana, Memecylon edule, Olea dioica, Terminalia chebula, Actinodaphne hookerii. The growth is generally stunted and the trees yield mostly firewood.

MANGROVE OR TIDE FORESTS

These occur over a negligible area on the fringes of creek traversing the west coast. The principal species are Rhizophora mucronata, Avicennia officinalis, Sonneratia apetala and Brugeiria conjugata. These are not of any commercial importance but are vital for prevention of erosion from floods and sand-storms.

MANAGEMENT OF FORESTS AND THE SILVICULTURE SYSTEMS

The important silvicultural system which is followed over major portion of Dry Deciduous forests and the better quality area of Dry Scrub Forests is simple coppice or generally "Coppice-with-reserve" system which has been found eminetly suitable for management of such forests. The poorer type of the scrub forests are generally managed for production of grass in which planting of fuel and fodder trees is prescribed. A major portion of such forests have been taken up for soil conservation and afforestation works under the Second Five Year Plan. In the Moist Deciduous forests, the system of management generally employed is either the "Uniform System" as in Chanda forests or the "Selection-cum-Improvement system"

with provision for artifical regeneration in suitable patches having little or no natural regeneration or advance growth. Most of the evergeen and semi-evergreen forests which are inaccessible and on steep slopes are included under Protection Working Circle and are completely protected and preserved. In the rest of the areas, generally, improvement fellings are carried out. As regards the Mangrove forests, they are not under any systematic management as they are mostly in charge of the Port Authorities or in charge of the Revenue Department.

THE PRINCIPAL PROBLEMS OF SOIL EROSION AND THE NEED FOR SOIL CONSERVATION MEASURES

In Maharashtra State, the problem of soil erosion is one of supreme importance needing immediate attention. The main soil erosion problems in the State are :

(1) *Shifting Cultivation* :

Shifting cultivation in the mountainous parts of the State by the aboriginal tribes was practised on a large scale till the end of last century. This practice was practically put a stop to by declaring the areas as Reserved Forests or Protected Forests under the Indian Forest Act and by setting apart specific areas for the practice of shifting cultivation or for rotational cultivation at intervals of 5 to 10 years as in Chandgadh area of Kolhapur Division. Some of the tribes were permanently settled in the Forest Settlements or Forest Villages where they are assigned suitable lands for permanent cultivation.

The weaning away of the forest tribes of shifting cultivation by the formation of Forest Settlements is a unique achievement. Shifting cultivation is almost non-existant at present in the forests of Maharshtra State.

However, the position has not improved in the private lands, especially the warkas lands or the marginal lands in the coastal belt where shifting cultivation with a rotation of about ten years is still practised. While travelling by the Phonda Ghat or the Amba Ghat in the months of April-May, it is very common to see the steep slopes facing west being burnt for shifting cultivation. Even the hill slopes where it is difficult for an ordinary person to stand erect are cultivated and the various operations are carried out with the help of a bamboo ladder. It is necessary to assess the extent of shifting cultivation and devise ways and means to control it. Steps are already being taken up to acquire malki lands in Ratnagiri District where shifting cultivation is at its worst. After the lands are acquired these will be afforested to arrest erosion.

(2) *Unauthorised cultivation in Forests* :

In recent years a number of cases of unauthorised cultivation in forest areas are reported from hilly evergreen to semi-evergreen forests of Kolhapur and Satara Divisions. The *modus operandi* usually consists of setting fire to the standing growth in the forests and cultivating the burnt area for a year or two. Generally the whole village takes part in such unauthorised cultivation. Though action has been taken to prosecute the offenders, it has not been possible to control such unauthorised cultivation. It is a fact that there is acute land-hunger in these areas and the people who resort to such unauthorised cultivation are generally poor. This does not, however, reduce the magnitude of soil erosion resulting in this hilly tract where the precipitation is over 150 inches. In the recent years we have taken steps to plant up the area as soon as it is cleared by the people. The species usedfor planting are *Bambusa arundinacea* and *Terminalia chebula*. These species

have shown initial success. As to how they will develop in future needs to be watched. As such areas receive more than 100" annual rainfall, cutting back all the damaged trees and completely protecting the area from grazing and fire results in luxuriant growth of herbacious as well as woody species completely covering the area and thus preventing erosion.

(3) *Coastal erosion* :

Maharashtra State has a coastal belt of about 450 miles. The erosion of land caused by sea wind and deposition of sand particles on the fertile agricultural land in the interior renders the latter infertile and gradually unsuitable for cultivation. Stabilisation of the coastal sand is necessary by raising extensive plantations of Casuarina and Cashew. The Forest Department has in its charge only small patches of land along the coast where it has scientifically carried out Casuarina plantations. These plantations have been of a very great help in binding the soil and preventing damage to private fields. The mangrove forests are in charge of the Revenue Department and the Port Authorities. Coastal erosion being a serious problem it is necessary that a thorough survey is carried out and suitable strip of land adjoining sea-shore handed over to the Forest Department for scientific management. However, this will take time but it is essential in order to bind the soil along the coast.

(4) *Stream-bank Erosion* :

In our State stream-bank erosion does occur along nallahs, streams and rivers. The main cause of such erosion is the destruction of protective cover along banks and over use of adjoining banks. A good plant cover on the banks would prevent much of this erosion. No systematic survey has been made to find out the extent and distribution of stream-bank erosion. However, the available reports indicate that the problem is fairly serious and needs urgent attention. The Forest Department has in its charge small patches along Mula-Mutha and Bhima rivers where systematic plantations of babul have been carried out successfully thus arresting erosion to very great extent.

(5) *River Valley Catchment* :

A number of Hydro-electric and irrigation projects have been undertaken under the Second Five Year Plan and are proposed to be undertaken even on a larger scale under the Third Five Year Plan. For the success of the above Projects, it is necessary to maintain the catchment area of various rivers well-clothed with vegetation. The extent of soil cover in the catchment areas and the actual area needing soil conservation measures needs to be assessed by detailed survey. Conservation measures would not only serve the reservoirs from silting but would help in ensuring sustained supply of water for agriculture and prevention of floods. A scheme for afforesting catchment areas is already in progress in Vidarbha. It is in its infancy and no data in its regard is available. But it is an interesting experiment and an excellent attempt to watch.

PROBLEM OF EROSION IN UPPER GHAT AREAS OF WESTREN MAHARASHTRA

In Western Maharashtra, large tracts of Malki lands, *i.e.* privately-owned lands are interspersed in between Government forests. The Malkidars own entire hill ranges extending over several hundreds of Square miles. These hill ranges vary in steepness and here we come face to face with the problem of erosion in lands, a large part of which should never have been brought under cultivation.

As these are privately owned lands there is very little that we can do to stop erosion even to delay the time when these lands will become unfit for cultivation. We cannot hope, by whatever action we may take to completely prevent destruction of land which has already been started by the shortsightedness of man. Acquiring of the malki-lands and their systematic management by the Forest Department appears to be the only solution in the present circumstances. But this too does not appear to be a possibility in the foreseeable future.

Before we deal with the soil conservation measures adopted, let us see what the Government forests are like in this area. The problem of erosion is at its worst in the dry and arid areas of the Maharashtra State. These include the denuded hills of the Deccan Plateau which forms a very large portion of the Western Maharashtra. The tract includes all the five Districts of Marathwada, *viz.* Aurangabad, Bhir, Nanded, Osmanabad and Parbhani and the nine Districts of Ex-Bombay State : *viz.* northern and eastern parts of Jalgaon, Northern Dhulia, Ahmednagar, Sholapur, eastern part of Nasik District, Poona, Satara, Sangli Districts and northern portion of Kolhapur District. Forests in this tract are classified as Dry Tropical Forests—Tropical Thorn Forests under the Champion's Classification of Forest Types.

SOIL CONSERVATION MEASURES

Against the above background the Forest Department had to devise ways and means to control the soil erosion in the Reserved Forest areas. It was only after independence that ambitious programmes were prepared and put into effect throughout the State. The appended list indicates the schemes undertaken and the areas attempted in Poona Circle.

In order to formulate scheme for arresting erosion all the practical measures were considered. It was decided that the most important single factor in preventing soil erosion is the production and maintenance of a complete vegetative cover over soil. In fact, it is mainly by interpreting, adapting and applying nature's ways to the present day conditions that the present soil conservation measures have been developed. Our principal soil conservation measures consist of afforestation. Other measures like contour trenching, contour furrowing, gully-plugging are principally meant for conserving moisture and for providing suitable seed bed, though these measures also have independent merit of thier own in conservation of soil. The reason for adopting afforestation as our principal method of controlling soil erosion is the well-known fact that trees produce heavy, deep and broad-spreading root system that helps to hold the soil particles together. In addition, trees also scatter over forest floor covering consisting of masses of leaves, dead twigs, limbs and even their own bodies. Trees also permit growth of other vegetation such as weeds, grasses, shrubs, vines and bushes. The supplementary growth makes the covering more effective in holding water and releasing it gradually to streams or other drainage channels. Trees are long lived and can, therefore, be depended upon as more efficient and reliable protection measure against erosion. Trees can usually be established easier and cheaper and more effectively than any other vegetative cover.

In raising trees we are faced with the twin problem of controlling erosion and conserving rainfall and for this purpose value of the land has to be recognised. Obviously, elaborate and costly measures can scarcely be justified when the land required to be afforested is of inherientlly low economic worth. Low annual rainfall is typical of the areas which we have to attempt and it is a factor that seriously limits the production of adequate vegetative cover. Torrential

quantity of infrequent rains compounds the problem of controlling run off. In addition many areas requiring treatment are difficult of access. In spite of these difficulties, a general method of attack on the problem of soil erosion has been developed. The moisture conservation measures adopt a definite pattern : (A) Construction of contour trenches ; (B) Contour furrowing or *uralies* ; (C) Construction of gully plugs and check dams.

(A) CONSTRUCTION OF CONTOUR TRENCHES

Drawing inspiration from the Gradoni system of afforestation, experimental work was started in 1939 in Khed Range of Poona Division. Here about 30 acres of badly denuded hills out of revenue waste-lands were taken up for continuous trenching 2′×2′—100 feet apart at the cost of about Rs. 3·50 per 100 running feet. Trenches were filled with soil with an inward slope of 1 in 3. These were planted up with Azadirachta indica, Acacia catechu, Hardwickia binata, *teak*, Albizzia lebbck, etc. Gully plugging and nalla-bunding work was also carried out. The results were very encouraging and this convinced the public as well as the authorities of the immense benefits in the form of increased agricultural crop-yields, higher water level in the wells in the fields of the agriculturists below and more sustained flow in the nallas and rivers from this water shed. This Department was also encouraged to extend this type of work in places like Chimangaon in Satara Division, and in other areas in East Nasik Division. Continuous contour trenching was also attempted in the Sangola Afforestation Scheme over an area of 80 acres. Grass seeds were also broadcast throughout the area. Of the species introduced Acacia, catechu, Azadirachta indica, Zizyphus jujuba, Acacia arabica, Gmelina arborea succeeded the best.

With the experience gained from continuous contour trenches, the Forest Department concentrated on perfecting and developing cheaper methods and technique and by stages the system of staggered contour trenches was developed. In this case, the individual trenches are 12′×2′×1′ along the contour and staggered with those in the next line which is usually 33 feet apart along the slope. After digging the trench of the above dimensions, soft and superficial earth excavated from it is kept on one side for refilling the trench while murrum and stones are stacked on the lower side of the trench to serve as base. The hill slope is then scraped and the excavated superficial earth mixed with soft earth obtained from the trench, is filled up to form surface which has 1 in 3 inward slope. The trench is then toed with boulders. Seeds are then sown at the places where depth of the soil is maximum for root penetration. Experience has shown that on an average we can have 30 such trenches per acre, leaving aside out-crops of rocks or areas where it is physically impossible to construct trenches. At the rate of Rs. 1·50 per trench the cost of construction of such trenches per acre is Rs. 45. Experience has also shown that this type of trenching not only gives us maximum moisture conservation but is also relatively cheaper. It has been mentioned above that seeds are sown at places which give maxium scope for root penetration. Originally thick sowing of seed was done in two rows 6 inches apart. Subsequently, it was found that such thick sowing is unnecessary as this not only leads to wastage of seed but the severe root competition inhibits satisfactory growth of plants. At present we are sowing seeds 6 inches apart in one line only. In addition three seedlings raised in polythene bags are also put in per trench. This gives the best results.

As considerable space was available in between the trenches it was thought best to utilize this space. A system of pits 1′×1′×1′ at 12×12′ in between

these trenches has now been developed. These pits are very useful for raising fodder and fuel yielding crops.

(B) CONTOUR FURROWING

In flatter and gentle undulating areas it was found that the costlier method of contour trenching can be very suitably replaced by the method of contour furrowing. Since contour furrows store rain water at or near the point where it falls they obviously have a definite value for flood-control. The cost of contour furrows varies with the implements used. Normally these are at the interval of 18 to 20 feet. In an acre we can get approximately 2,000 running feet of such furrows, costing Rs. 12 per acre. The method adopted is to plough a strip about four feet in width. The ploughed earth on the strip is broken up and stones, etc. removed. The earth is then collected in the centre to form a bund having base of 18″ to 24″ and height of 9 to 12 inches with cross-sections of isosceles triangle. Seeds are sown on the apex of the triangle. Where possible, forest species are raised through agri-silviculture for the mutual benefit of the landless and for saving the cost to the Department. However, we have to be very careful in giving land on agri-silviculture as due to extreme land-hunger once the people enter into land it is very difficult to oust them. In between furrows we are taking two types of pits : that is saucer type of pits and the half-moon trench type pits. These have proved very successful, even more successful than the 1′ × 1′ × 1′ pits in between trenches on steeper slopes.

(C) GULLY PUGS AND CHECK DAMS

Gully plugs and check dams have been constructed at various places in the gullies and nallas. The plugs and dams usually consist of dry rubble walls. The interval in between the plugs or dams varies according to the slope and width of the gully. Height of such plugs at the highest point is about one foot. Various successful results have been achieved in the afforestation areas of Barshi, Ahmednagar and Malshiras by constructing such plugs. In areas where there is dearth of stones earth plugs have been put across the shallow depressions and gullies. For this purpose a small trench 1 foot deep and 2 feet wide is taken across the gully. Earth is then filled into this trench and the height of the bund raised to one foot above the ground surface. Agave suckers are sown on such bunds. These bunds are very cheap to construct and serve the purpose of breaking the force of water. It is observed that even with this obstruction gullies are gradaully being silted up. When the silting is complete, sissoo stumps are usually put in which develop very well indeed.

CHOICE OF SPECIES

The choice of species in the afforestation areas is a delicate problem. In arid areas the surface soil is already washed off. Contents of nutrient materials are considerably reduced in the soil in trenches, furrows or pits. Planting possibilities in any area depend not only on the textural characteristics of the soil but al so on many other factors such as topography, water level, petrographic conditions of the soil, contents of organic matter et cetera. Therefore, knowledge of planting possibilities is to a great extent a matter of local experience derived from the observation of both natural distribution of trees in the area and the results obtained in the older plantations. Originally the following 34 species were prescribed for direct sowing :

1. Acacia arabica
2. Acacia catechu
3. Azadirachta indica
4. Acacia leucophloea
5. Zizyphus jujuba
6. Tamarindus indica
7. Prosopis specigera
8. Prosopis juliflora
9. Acacia modesta
10. Pongamia glabra
11. Butea frondosa
12. Cassia siamea
13. Albizzia lebbek
14. Dalbergia sissoo
15. Swietinia mahogany
16. Chloroxylon swietenia
17. Sapindus trifoliatus
18. Gmelina arborea
19. Melia azadirachta
20. Phyllanthus emblica
21. Annona squmosa
22. Pterocarpus marsupium
23. Holoptelia intergrifolia
24. Feronia elephantum
25. Mangifera indica
26. Aegle marmelos
27. Bassa latifolia
28. Hardwickia binata
29. Eucalyptus spp.
30. Santalum album
31. Diospyros montana
32. Buchanania latifolia
33. Tectona grandis
34. Eugenia jambolana.

In addition sissoo and teak stumps were also recommended. Our observations have shown that Acacia arabica can only be used successfully in black-cotton soil. It does not do well at all in soil containing lime or lateritic kunker. Leaving aside black-cotton soil, sissoo stumps or their cuttings raised in polythene bags, Eucalyptus hybrid raised in polythene bags, Gmelina arborea by direct sowing, Acacia catechu by direct sowing, Hardwickia binata by direct sowing, Bauhinia variegata rasied in polythene bags give by far the best results. In recent years, therefore, our attention is confined to these few species at the exclusion of other species given in the above list. Prosopis juliflora has not proved to be a very promising species. It flourishes if the soil is deep, black-cotton but in such areas babul is invariably preferred as it is far more valuable. Cassia siamia is another species which we are omitting from our list of afforestation species. Even in poor areas Cassia siamia grows very well but it tends to suppress other valuable species. As fuel Cassia siamia has very little local demand. In its place Eucalyptus hybrid raised in polythene bags is far more preferable. In our afforestation areas we have been using sandal seeds on very large scale and these are dibbled under Lantana bushes that are found in abundance in our afforestation areas. As our afforestation schemes are still young it is difficult to forecast as to the future of such sandal dibbling. But this species is certainly giving very encouraging results. We have also tried Gliricidia maculata with great degree of success, particularly in Barshi afforestation area. In the scheme for afforestation and beautification of Ajantha and Ellora caves we have tried Poinicia regia, Jacaranda mimosaefolia, Spathodia campanulata, Peltophorum ferrugineum, Casuarina equisetifolia. All these species have shown very good initial success as the plant under the scheme are watered regularly. As these species are mainly for beautification, they cannot be considered as our regular afforestation species. It is observed that *gulmohor* particularly, even without watering, comes up successfully.

We have introduced stakes of Ficus species and *salai* in our afforestation areas. Observations however show that the stakes do not take unless they are

watered during the hot weather. Stakes in Ajantha and Ellora areas where watering is done are nearly 100% success as against this, stakes put in other areas, where no watering is done, are a total failure.

Kaju is a newcomer so far as our afforestation works are concerned. In suitable localities like Ghod Valley, kaju is showing promising results. Howeve, its future development will have to be watched before any definite conclusions are reached.

Under the various schemes for improvement of grasses and grazing areas in addition to the improvement works better fodder grasses are being introduced in ploughed lands in between furrows and trenches at an interval of about six to ten feet. Seeds of grasses like Blue panic, Thin napier, Rhodes, etc. are being tried in these lands along with better local varieties. On the steeper slopes tussocks are being planted up in pits 4′×4′. Results are being watched.

COST OF OPERATION

Details of expenditure for afforesting one acre area either by means of furrows or trenches is as under :

S. No.	Particulars of work	Quantity	Rate	Per	Amount
1.	Cost of making furrows	2000 Rft		lump	12·00
2.	Cost of digging and filling in pits as described in the scheme	300 Pits	5000	100 pits	15·00
3.	Cost of gully plugging	Lump	3·00	acre	3·00
4.	Cost of seed	3 lb.	0·50	lb	1·50
5.	Cost of sowing and resowing				1·50
6.	Cost of 2 weedings and mulching				6·00
7.	Cost of fire tracing				0·50
	Ist Year—Total for one acre of planation in bunds :				24·50
	Ist Year—Total for one acre of plantation in pits :				27·50
	or				
	IInd Year :				
8.	Cost of seed	1 lb.	0·50	lb.	0·50
9.	Cost of sowing and resowing				0·50
10.	Cost of 2 weedings and mulching				5·00
11.	Cost of fire tracing				0·50
	IInd Year—Total cost for 1 acre of plantation :				6·50
	IIIrd Year :				
12.	Cost of fire tracing				0·50

S. No.	Particulars of works	Quantity	Rate	Per	Amount
	IVth Year :				
13.	Cost of fire tracing				0·50
	Vth year :				
14.	Cost of fire tracing				0·50
	Total cost upto five years for one acre of plantation in bunds :				32·50
	or				
	Total cost of five years for one acre of plantation in pits :				35 50

Details of expenditure of raising plantations in trenches

S. No.	Particulars of works	Quantity	Rate	Per	Amount
	Construction of staggered contour trenches 2′ broad 1′ deep and 12′ long	30 Trenches	1·50	Trench	45·00
2.	Gully plugging	Lump	3·00	Acre	3·00
3.	Cost of seed	One lb.	0·50	lb.	0·50
4.	Cost of sowing and resowing	30 Trenches	0·50	Trench	1·50
5.	Cost of weeding and soil mulching				5·00
6.	Cost of fire tracing				0·50
	Total for 1st year of plantation in one acre :				55·50
	IInd Year :				
	Cost of seed and resowing				0·50
8.	Cost of two weedings and mulching				4·00
9.	Fire tracing				0 50
	Total for IInd year of plantation in one acre :				5·00
	IIIrd Year :				
10.	Cost of fire tracing				0·50
	IVth Year :				
11.	Cost of fire tracing				0·50
	Vth Year :				
12.	Cost of fire tracing				0·50
	Grand total for five years for raising One acre Plantation :				62·00

Area Attempted under Afforestation Schemes

S. No.	Name of the scheme	Target achieved	Acre
1.	Scheme for afforestation of Reserved Forest in selected Talukas of Ahmednagar District	Plantation	1400
		Kuran formation	2173
2.	Afforestation Scheme for Barshi Taluka of Sholapur District.	Plantation	1577
3.	Afforestation of areas within 1 mile radius of Sinhagad Fort.	Plantation	390
4.	Afforestation of arid and blank areas at Khadakwasala in Poona Division.	Plantation	90
5.	Scheme for afforestation-cum-soil Conservation at Katraj.	Plantation	263
6.	Afforestation Scheme in Ghod Valley in Poona Forest Division.	Plantation	500
7.	Afforestation Scheme for Sangola Taluka of Sholapur District.	Plantation	140
8.	Afforestation Scheme for Malshiras Taluka of Sholapur District.	Plantation	1533
		Kuran-Formation	682
9.	Scheme to increase and to improve forests in Jath Taluka of South Satara District.	Plantation	40
10.	Afforestation Scheme for denuded areas of Satara Taluka.	Plantation	892
1.	Afforestation Scheme for Panhala Hill Station.	Plantation	338
2.	Afforestation of Blank and sparsely wooded areas in East-Khandesh Division.	Plantation	525
3.	Scheme for beautifying Hill sides around Ajantha Caves.	Sandalwood Plantation	442
4.	Scheme for planting Ornamental trees and Afforestation around Ellora Caves.	Sandalwood-dibblings	650
5.	Development of Maismal Plateau.	Afforestation	300
		Plantation	30
6.	Afforestation and rehabilitation of Pasture lands.	Plantation	226
7.	Afforestation and Anti-erosion works in dry and eroded lands in Aurangabad and Nanded Divisions.	Plantation	4838
		Total	7298

SOME IMPORTANT BIOTIC FACTORS OPERATIVE IN SAL (SHOREA ROBUSTA) FORESTS OF UTTAR PRADESH

By

H. P. BHATNAGAR

Forest Research Institute, Dehradun

Plant ecology is the science of plants, which aims to discover reasons for the occurrence of certain species in special localities and the effects of the plants themselves, on their habitats.

There are four chief groups of factors that determine the special characteristics of any habitat. They are :

Edaphic Factors : They relate to physico-chemical nature of soil, and such ingredients as water, air, humus, etc.

Climatic Factors : These are concerned with the duration and intensity of sunlight, temperature, wind, rainfall, humidity, etc., of the atmosphere.

Topographical Factors : Such factors include the height above sea-level, ground slope, aspect, position with regard to mountains, etc., etc.

Biotic Factors : These are all the influences exerted by living things.

In forests, which are in close vicinity of habitations, as we find in Uttar Pradesh, the most potent factors, controlling the nature of habitats are the biotic factors. Fortunately, these are also the factors which can be easily manipulated to suit the desired composition and growth of vegetation.

The important biotic factors, operative in the sal (*Shorea robusta*) forests of U. P. are as follows :

(*i*) *Fire* : Forest fires are mostly due to human agency, although as a rare case they may be caused by lightning. Again, they are unintentional, except when the *bhabhar* (*Ischaemum angustifolium*) grass cutters introduce conflagration, under the belief of improving the pasture. These fires usually take a severe turn and cause the maximum damage to forest growth. Very often the departmental burning operation, as well, creates a nucleus of extensive forest fires, if the desired precautions are neglected. Ignorant villagers, while camping or passing through a forest, leave fire unquenched, which spreads widely.

Adverse effects of fires are many and the most obvious is the total destruction of forest litter and humus, which changes not only the chemical composition of the soil but also its physical character, if the fires recrudesce frequently. Thus, a degeneration is set in, which is not so easy to remedy. Dessication is also apparent and as the protective soil cover is lost, erosion follows in its wake. Damage to regeneration of tree species is extensive, and in particular to that of sal, which has a natural tendency to die-back. Usually the burnt over areas abound in grass and very often a secondary retrogression is set in, which causes abundance of shrubs like *Clerodendrum infortunatum, Mallotus philippensis, Milletia auriculata,* etc. to the inhibition of sal regeneration.

(*ii*) *Forest fellings* : Illicit fellings, sometimes assume a big magnitude, especially in marginal forests, abutting the habitations. These fellings, being extremely selective in nature, change the floristic composition of the forest and usually the useless species and stems are left to perpetuate.

Also if the silvictulural system adopted for the management of the forests is unsuitable, very serious results may occur. Instances of reducing a forest cover to a grassland are not uncommon, due to this reason. Usually the silvicultural systems are designed to meet the sustained exploitation of forest, without impairing the locality factors and in maintaining the ecological status.

(*iii*) *Grazing by domestic animals* : Uncontrolled or excessive grazing has very serious adverse effects on the regeneration of sal and other forest tree species. Grazing is a necessary evil to meet the demands of people, and very often even overgrazing is allowed knowingly, as the rights and privileges of people cannot be curtailed. Trampling and browsing of regeneration, are common and soil is hardened to disfavour germination. Erosion is accentuated and thorny shrubs like *Carissa opaca and Zizyphus spp.* increase proportionately, being self-depend and unpalatable. Excessive grazing also arrests seral development of vegetation and sometimes retrogression is caused. These damages are of far-reaching consequences.

(*iv*) *Lopping* : Considerable damage is done to the trees by Gujars, graziers and camelmen who lop the trees mercilessly. Repeated lopping of the forest types in Mchand and Barkala ranges of Saharanpur division proved very destructive and in a number of cases the lopped trees have died.

Browsing and nibbling animals do great damage to the forest saplings and often on a very extensive scale. All browsing animals tend to encourage the growth of hemior pyophytic grasses, because such life forms are not killed but are stimulated to new vegetative growth. Due to repeated browsing certain tree species are converted to a bushy form by repeated distruction of leading shoot, which stimulates sprouting of lateral buds leading to the formation of multiple axes.

The excessive damage to sal forests is done by Sambhar, Chital, Kakur, Nilgai, Gond and other browsing animals. Sambhars are worst browsers, chital in larger herds are most destructive to natural and artificial regeneration and coppice shoot of *Shorea robusta, Terminalia tomentosa, Adina cordifolia,* etc. In Kotah range of Ramnagar division browsing is responsible for the total failure in restocking a number of areas under concentrated regeneration. This failure has proved of a lasting nature at several places.

Wild elephants are also very destructive to sal forest, in pole stage, *e.g.*, in Barkot and Motichur ranges of Dehra Dun division, Boribara and Mohan ranges of Saharanpur division and in Haldwani forest division.

Young sal shoots are frequently found stripped of their bark or are girdled, for which porcupines are largely responsible. Pigs also cause damage to sal and other trees by gnawing the bark. Such damage is noticeable in sal plantation of Haldwani division. Monkeys have also been noticed doing wanton damage to sal seedlings in plantations by uprooting and breaking them in the south Kheri forest division.

Insects also, sometimes, cause great damage to sal forest. By far the most seriously damaging insect in sal forests is sal borer, longicorn beetle (*Hoplocerambyx spinicornis*). It appeared as an epidemic in the Thano range of Dehra Dun division in 1916, and its activities lingered on during many subsequent years. The loss calculated, was over rupees 2½ lakhs. In 1916–17, a survey of injurious forest insects carried out in Gorakhpur division recorded *Sphaerotrypes siwalikensis* (sal bark beetle), *Xylotrechus smei* (Heart wood borers) *Diorthus oinereus, Dialeges pauper* and *Aeolesthes holosericea.* In Gorakhpur also *Gielosterpa scabrator* caused damage by gnawing the leading shoots of sal. In nurseries, principal insect pest of sal seedlings are grass hoppers, Teratodes and Aularches.

Defoliating insects like *Ascotis selenaria Amparata* are also very common and they sometimes do much damage by eating leaves and tender shoots of sal. In 1925 and again in 1934 the Motichur forest of Dehra Dun division are said to have suffered from serious attack of defoliating insects. Principal defoliators in Gorakhpur division, as recorded in 1918–19, are *Ingura subanicalis* and *Holotrichia spp.* White ants are also quite common throughout well drained forests. They are harmful in nurseries and plantations to young sal plants.

Plants : Biological activity of plants exercise a perfound influence on one another and on soil development. Plants tend to maintain the fertility of a soil by translocating minerals from the deeper layers and returning them to the surface. The process of humification, nitrification are of fundamental importance in the building up of soil fertility. As regards influence on one another, every plant competes particularly for available soil moisture, soil minerals and for space to grow. It is an established fact that weeds do exert substantial inhibiting influence on the growth of young tree seedlings mainly by utilizing soil moisture by transpiration specially during critical periods of drought conditions and by utilizing soil minerals (Bhatnagar 1960 and 1961).

Fungi : Fungus also does a considerable damage to the forests except in natural mixed forests where its activities are counter-balanced. Prevalent fungus damage is found in the sapling and pole stages of sal. Rot in mature and overmature trees is also common.

Climbers do considerable damage to sal saplings and poles. The most common climbers are *Milletia auriculata, Tiliacora racemosa, Bauhinia vahlii, Spatholobus roxburghii, Ichnocarpus frutescens* and *Pueraria tuberosa.* Climbers are kept under control by repeated cutting under various cultural operations. In South Kheri forest division *Milletia auriculata* and *Tiliacora recemosa* together with *Mallotus philippensis* form dense impenetrable thickets, which restrict the natural regeneration of sal.

There is appreciable competition between the larger trees and sal seedlings as well as between herbs and shrubs and sal seedlings, (Bhatnagar and 1960). The competition between herbaceous and shrubby vegetation 1959, sal seedlings is of a much greater magnitude than competition between the trees and seedlings. The growth peaks of sal seedlings occur during 15th April—16th May, 15th June—15th July and 15th August—15th September, the first and last being more important. Since during these periods the demand of actively growing sal seedlings are maximum, the competition from other plants is intense. If weedings are carried out during these periods or somewhat in advance, *i. e.*, in late winter or early summer and or in late rains, they will help to relieve the intense competition between the sal seedlings and associated ground flora and lead to accelerated growth of the former.

Parasitic plants do occur in the forests but not in great number and thus do little damage to the sal forests. *Loranthus longiflorus* (Banda) is the commonest of them all, specially recorded in good number in Motichur Range of Bahraich division and in South Kheri forest division. *Ficus* species occur epiphytically but the damage done by them is not much.

Mallotus philippensis in particular and *Clerodendrum infortunatum* and other weeds in general deprive sal of the available moisture and also cause accelerated depletion of soil moisture, which might otherwise have been adequate for a longer period. Therefore, cutting of weeds specially of *Mallotus philippensis* bushes in the early summer before rains, *i.e.*, in April–May when the period of greatest competition for soil water is beginning and which is also the period of maximum growth of

sal seedlings, and again in winter. *i.e.*, in November and December when there is renewed competition, although of lesser magnitude for soil water, will help in the better development of sal seedlings.

ADVANTAGES CONFERRED BY BIOTIC FACTORS

Besides the damage done to the forests by the forest biota, there are some beneficial effects of them as well. Earthworms pass humus through their elementary canal and thereby aid in its decomposition. They also make the soil porous due to their movement in the soil and thus increase the aeration. Many other invertebrates which live in the soil such as snails, slugs etc. are also beneficial like earthworms. In the uppermost layers of soils specially in humified layer bacteria abound. Some of them, which fix the atmospheric nitrogen and make it available to plants, are of immense benefit for plant. Leguminous plants with root tubercles, also contain bacteria. Such bacterial noduls are also found in Alnus and plants of Elaeagnaceae.

Pigs also play a beneficial role in sal forests by digging forest soils in search of insect larvae, tubers etc. and thus forming natural seed beds. A beneficial effect of fire is also noticed in suppressing the growth of *Mallotus philippensis* which prevents by the establishment and development of sal seedlings. The phenomenon is evident in the South Kheri and North Kheri forest divisions.

ACKNOWLEDGMENTS

My grateful thanks are due to Shri S. K. Seth and Shri M. A. Waheed Khan for their criticism ; thanks are also due to Dr. G. S. Puri for suggestions.

REFERENCES

Beeson, C. F. C. 1941. The Ecology and control of Forest Insects of India and neighbouring Countries. Government Publications.

Bhatnagar, H. P. 1959. The effect of root competition on the growth of sal natural regeneration *Ind. For.* Vol. 85, No. 7, 1959, pp. 408–14.

———1958. Ecologico-physiological studies of *Shorea robusta* of U. P., Ph.D. Thesis Agra University, Agra.

———1960. Studies on comparative utilization of available moisture by sal (*Shorea robusta*) and some associated weed species. *Agra Univ. J. Res.* (*Sci.*) Vol. IX. Part 2, pp. 261–270, 1960.

———1961. Sand culture experiments on sal (*Shorea robusta*) seedlings. *Proc. 48th Indian Sci. Congress. Part III.*

PROBLEMS IN AUTECOLOGY OF WEED FLORA OF INDIA
1. ECOLOGY OF *ACHYRANTHES ASPERA* LINN.

By

P. S. RAMAKRISHNAN

Dept. of Botany, Meerut College, Meerut

Like synecology, autecology of individual plants is of great interest in the tropics because a number of plants are of medicinal and other values. In this paper autecology of *Achyranthes aspera* Linn., a medicinal plant is given.

A number of species have been worked out in the laboratory of Benares Hindu University. These studies show a need for planned research work in this subject.

INTRODUCTION

The importance of the necessity for an 'Ecological flora' or 'Biological flora' for this country has been stressed by Misra (1958). With this aim in view, ecology of ten common weeds of Varanasi has been worked out, as a preliminary contribution to the ecological flora of Varanasi District (Ramakrishnan, 1959). The ecology of *Achyranthes aspera* Linn., as presented in this paper is a further contribution to this series of investigations besides the account already appeared on few other species (Misra and Ramakrishnan, 1959, Ramakrishnan, 1960 a, b, c).

A. aspera is herbaceous annual weed of way sides and waste places growing to a height of 30 to 127 cm., with long spreading branches. The plant is distributed throughout India and Ceylon. The distribution is pantropical.*

SIZE AND WEIGHT OF SEEDS

The seeds of *A. aspera* have an average weight of 4·5 mg. The length of the seeds varies from 1·692 to 2·944 mm. and breadth from 1·308 to 1·590 mm. The shape index expressed as length/breadth ratio varies from 1·1 to 2·3. Mall and Arzare (1956) report an average weight of 11·0 mg. and an average length of 4·2 mm. and breadth of 1·3 mm. These values are very high and appear to be unlikely.

Environmental Factors :

Moisture content—The plants grow in drier situations and they do not tolerate water-logging.

pH—The plants grow in alkaline soils (pH 7·2 to 8·0).

Carbonate content—The carbonate content ranges from 0·20 to 1·93 per cent.

Exchangeable calcium—The plants are found to thrive in calcareous as well as non-calcareous soils. A range of 6·48 to 29·50 m.e. per cent has been obtained for this factor.

Nitrate content—The plants thrive in nitrogen rich as well as nitrogen poor soils (2·25 to 6·25 mg./100 g. of soil).

*This information was obtained from the Director, Royal Botanic Gardens, Kew, Richmond, Survey.

Organic matter—A range of 3·68 to 5·30 per cent has been obtained for this factor. Mall and Arzare (1956) obtained values as high as 15·99 per cent for this species at Sagar.

Performance of the Plant in Different Localities :

The data regarding the performance of the plant in different localities., *viz.*, Rajghat, Latifshaw, Ramnagar, Lanka, Sarnath, Akhari shows a range in the height of plants 82·3 to 127 cm., length of spike 16·0 to 36·2 cm., average number of spikes 12 to 47, average number of seeds per spike 58 to 82, seed output 816 to 3854.

No correlation could be established between the soil analysis data and performance of the plants. It is, however, to be noted that the length of the spike is a very variable feature (16 0 to 36·2 cm.). The influence of *Cassia tora* associate on the seed output of the species is discussed under 'Biotic factors'.

Associates :

The associates of *A. aspera* in different localities are : *Achyranthes aspera, Aerua scandens, Amaranthus spinosus, Anisomeles ovata, Apluda mutica, Boerhaavia diffusa, Cassia occidentalis,* C. *tora, Corchorus acutangulus, Crotalaria medicagenia. Dactyloctenium aegyptium, Digitaria longiflora, Dichanthium annulatum, Eleusine indica, Eragrostis tenella, Euphorbia hirta, Justicia simplex,* J. *quinqueangularis, Linaria ramosissima, Peristrophe bicalyculata, Rhynchosia minima, Sida acuta,* S. *rhombifolia, Triumfetta neglecta, Urena lobata.*

Biotic Factors :

It is seen that *Cassia tora* forms a very common associate of *A. aspera.* In localities where *A. aspera* grows in association with *Cassia tora* the former exhibits good growth and high seed output. This is accounted as due to the protection offered to the former, in such areas, against exposure and grazing. In those arear where the grazing animals freely operate, plants exhibit poor growth and poor seed output. The significance of *Cassia tora* in the growth of *A. aspera* has also been recognized by Mall and Arzare (1956).

Seven fungal parasites are recorded on this species from India, *viz., Albugo bliti, Cercospora achyranthes**, *C. achyranthina, Physalospora achyranthis, Ramularia* sp.* *Septoria achyranthis, Vestergrenia achyranthis**.

Phenology :

The seedlings of *A. aspera* come up in nature, by the end of July, after the first few showers. Hence, the seedling stage is passed when they are rooted in fairly moist substratum. The spikes come out by the middle of September and flowering and fruiting continue up to the end of January when the plants begin drying up.

Germination of Seeds:

Seeds collected in November, 1958 were used in the germination studies.

Seeds put for germination in December, 1958 were not able to germinate successfully. The testa burst open and the radicle came out as a small protuberance. Beyond this, further development did not take place. This too happened only with 4 per cent of the seeds put for germination.

*This information was obtained from the Head of the Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi.

Seeds put for germination on the 26th February, 1959 gave 54 per cent germination in diffused day light. Hence, it is seen that the seeds have a dormancy period of only about 2½ to 3 months. It may be mentioned here that Mall and Arzare (1956) have noted a dormancy period of 6 to 8 months for this species

Seeds were put for germination on the 26th June, 1959 under the following conditions in : (*i*) diffused daylight and darkness at night by the side of a window, (*ii*) continuous light of an electric bulb and (*iii*) continuous darkness inside a chamber.

It is seen that the percentage germination is higher in light than in darkness. Furthermore the amount of light does not matter in germination.

Reproductive Capacity :

The average seed output of *A. aspera* is 1926, and the percentage germination is 72. The reproductive capacity for the species works out to 1387.

Epidermal Structure and Stomatal Frequency of Leaves :

There are closely appressed hairs on the lower side of the leaves, more abundantly in the case of 'sun' leaves.

The lower epidermal cells are more wavy in surface view than the upper epidermal cells. Stomata are present on both surfaces of the leaves and the frequency is greater on the lower side than on the upper side. Moreover, the stomatal frequency is higher in 'sun' leaves than in 'shade' leaves.

Dispersal of Seeds :

The flowers are stiffly reflexed against the rachis of the long spike. The bracts, bracteoles and perianth lobes are also rigid and spiny so that the fruits get attached to the clothing of man and sometimes to the body of animals. Ridley (1930) reports that the seeds are dispersed by birds also.

Seedling Morphology :

The seeds are sub-cylindrical. At the time of germination, the radicle projects out as a small protuberance from one side of the seed. When the radicle is a few mm. long, the hypocotyl elongates in the form of a hook and in this process, the cotyledonary leaves, still enclosed within the membranous testa, are carried up the surface of the soil. The cotyledonary leaves are long and linear with a pinkish tinge. The leaves that come out later have the size and shape of the adult plants.

Economic Importance :

Kirtikar *et al* (1935) attributes the following medicinal properties to this species :

The plant is laxative and is considered useful in dropsy, piles, boils, eruptions of the skin, etc. The seeds and leaves are considered emetic and are useful in hydrophobia and snake bites. The ash of the plant is used externally in the treatment of ulcers and bites of insects. The plant is useful in hysteria and such nervous disorders.

DISCUSSION

Achyranthes aspera Linn. thrives best in *Cassia tora* communities and this appears to be due to the protection given to it against exposure and grazing, an observation made also by Mall and Arzare (1956). *A. aspera* is indifferent to exchangeable calcium in the soil.

The seeds have a dormancy period of 2½ to 3 months. In the case of fres seeds only 4 per cent germination was obtained even which was partial. The radicle protruded out but its further elongation and growth did not take place This may be due to the low temperature available during the winter months.

Stomatal frequency has been found to be higher in 'sun' leaves than in 'shade' leaves.

REFERENCES

Kirtikar, K. R. *et al.* 1935. *Indian Medicinal Plants.* 4 Vols. Allahabad.

Mall, L. P. and Arzare, K. C. 1956. Autecological study of *Achyranthes aspera* Linn. *Bull. bot. Soc.*, Univ. Saugor **8** : 69–76.

Misra, R. 1958. The concept of Biological Flora. *Mem. Indian bot. Soc.*, **1** : 122–126.

Misra, R and Ramakrishnan, P. S. 1959. Distribution of *Peristrophe bicalyculata* Nees in relation to soil nitrogen and light. *Curr. Sci*, **28** : 340.

Ramakrishnan, P. S. 1959. *Contributions to the Ecological Flora of Varanasi District.* Doctoral Thesis, Banares Hindu Univ.

——— 1960a. Ecology of *Eclipta alba* Hassk. *Proc. nation. Inst. Sci.*, **26B** : 191–204.

——— 1960b. Ecology of *Echinocloa colonum* Link., *Proc. Ind. Acad. Sci.*, **52B** : 73–90.

——— 1960c. Studies in the autecology of *Euphorbia hirta* Linn. *J. Indian bot. Soc.*, **39** :

Ridley, H. N. 1930. The Disperal of Plants throughout the World. L. Reeve & Co., Ltd., Ashford, Kent.

Salisbury, E. J. 1932. The interrelations of soil, climate and organism and the use of stomatal frequency as an integrating index of the water relations of the plant. *Beih. bot. Zbl.*, **49** : 408–420.

ECOLOGICAL OBSERVATIONS ON *ACHYRANTHES ASPERA* LINN.[1]

By

P. S. RAMAKRISHNAN

Department of Botany, Meerut College, Meerut.[2]

Ramakrishnan (1960*a*, *b*, *c*, 1961*a*, *b*) and Misra and Ramakrishnan (1960) have worked out the ecology of a number of herbaceous weeds as a preliminary contribution to the 'Ecological Flora of Varanasi District'. The autecology of *Achyranthes aspera* Linn. as presented in this paper is a further contribution to this series of investigations.

Achyranthes aspera Linn. is a herbaceous annual weed of way sides and waste places growing to a height of 30–127 cm. with long spreading branches. The plant is distributed throughout India and Ceylon (Hooker, 1872–1897). The distribution is pantropical.[3]

SIZE AND WEIGHT OF SEEDS

The seeds of *A. aspera* have an average weight of 4·5 mg. The length of seeds varies from 1·692 to 2·944 mm. and the breadth from 1·308 to 1·590. The shape-index expressed as length/breadth ratio varies from 1·1 to 2·3. Mall and Arzare (1956) report an average weight of 11·0 mg. and an average length of 4·2 mm. and breadth of 1·3 mm.

GERMINATION OF SEEDS

Seeds collected in November, 1958 were used in germination studies, in petri dishes, in between moist filter papers.

Seeds put for germination in December, 1958 were not able to germinate successfully. The testa burst open and the radicle came out as a small protuberance. Beyond this, further development did not take place. This too happened only with 4 per cent of the seeds put for germination.

Seeds put for germination on 26th February, 1959, gave 54 per cent. germination in diffused day light. Hence, it could be suggested that the seeds have a dormancy period of only 2½ to 3 months.

Seeds were put for germination on the 26th June, 1959, under the following conditions in (*i*) diffused day light and darkness at night by the side of a window, (*ii*) continuous light of an electric bulb and (*iii*) continuous darkness inside a chamber (Table I).

---

1. Part of a thesis accepted for the Ph.D. degree of the Banaras Hindu University.
2. Present Address : Department of Botany, Panjab University, Chandigarh-3.
3. This information was obtained from the Director, Royal Botanic Gardens, Kew, Richmond, Surrey.

TABLE I

Germination of seeds of *A. aspera* under varying light conditions

Date	No. of seeds germinated out of 50		
	Continuous light	Diffused day light	Continuons darkness
1-6-59	0	8	0
2-6-59	0	12	0
3-6-59	4	1	0
4-6-59	4	2	0
5-6-59	6	6	0
6-6-59	8	3	6
7-6-59	2	0	2
8-6-59	2	1	3
9-6-59	1	0	1
10-6-59	1	1	0
11-6-59	4	2	0
16-6-59	0	0	5
17-6-59	3	0	0
18-6-59	1	0	1
19-6-59	0	0	3
21-6-59	1	0	1
22-6-59	0	0	1
23-6-59	0	0	1
Percentage germination	74	72	48

It is seen that the percentage germination is higher in light than in darkness.

REPRODUCTIVE CAPACITY

Salisbury (1942) defines reproductive capacity as the product of the seed output and the fraction representing the percentage germination. The average seed output of *A. aspera* is 1926, and the percentage germination is 72%. The reproductive capacity for the species, therefore, is 1387.

DISPERSAL OF SEEDS

The flowers are stiffly reflexed against the rachis of the long spike. The bracts, bracteoles and the perianth lobes are also rigid and spiny so that the fruits get attached to the clothing of man and sometimes to the body of animals. Ridley (1930) reports that the seeds are dispersed by birds also.

SEEDLING MORPHOLOGY

The seeds are sub-cylindrical. At the time of germination, the radicle projects out as a small protruberance from one side of the seed. When the radicle is a few mm. long, the hypocotyl elongates in the form of a hook and in this process, the cotyledonary leaves, still enclosed within the membranous testa, are carried up the surface of the soil. The cotyledonary leaves are long and linear with a pinkish tinge. The leaves that come out later resemble those of the adult plants.

EPIDERMAL STRUCTURE AND STOMATAL FREQUENCY OF LEAVES

There are closely appressed hairs on the lower surface of the leaves, more abundantly in the case of 'sun' leaves. The lower epidermal cells are more wavy in surface view than the upper epidermal cells. Stomata are present on both surfaces of the leaves and the frequency is greater on the lower side than on the upper side. Moreover, the stomatal frequency is higher in 'sun' leaves than in the 'shade' leaves (Table II).

TABLE II

Stomatal frequency and stomatal index in 'sun' and 'shade' leaves of *A. aspera*

S. No.	Upper epidermis		Lower epidermis		Stomatal index	
	Stomata per sq. mm.	Epidermal cells per sq. mm.	Stomata per sq. mm.	Epidermal cells per sq. mm.	Upper surface	Lower surface
I	65	630	250	870	9·4	22·3
II	74	639	269	907	10·4	22·9
III	65	630	269	1055	9·4	20·3
I	37	463	204	722	7·4	22·0
II	46	481	176	630	8·7	21·8
III	37	444	213	759	7·8	21·9

OSMOTIC PRESSURE OF THE PLANT SAP

Osmotic pressure of the plant sap was determined by the cryoscopic method (Loomis and Shull, 1937). The osmotic pressure value of the plant sap increases with a decrease in moisture content of the substratum and the range is shown in Table III.

TABLE III

Osmotic pressure of sap of *A. aspera*

Locality	Moisture content of soil (%)	Osmotic pressure of plant sap (atmos.)
I	2·3	18·581
II	4·9	16·000
III	13·1	15·097

ENVIRONMENTAL FACTORS

Edaphic.—The soil analysis data for collections from different localities in Varanasi District are given in Table IV. The methods of analysis of soil followed is mentioned elsewhere (Ramakrishnan, 1960*a*).

TABLE IV

Soil analysis data from six localities, situated in Varanasi District, where *A. aspera* was growing profusely.

Locality	Moisture content (%)	pH	Carbonate content (%)	Exchangeable calcium (m.e.%)	Nitrate content (mg./100g. of soil)	Organic matter (%)
Rajghat	4·8	7·4	0·55	29·50	2·625	5.04
Latifshaw	5·9	7·8	1·93	6·48	6·250	5·30
Ramnagar	8·2	7·2	0·24	20·66	2·875	4·22
Lanka	12·2	7·4	0·23	16·38	5·500	4·74
Sarnath	9·6	8·0	0·80	21·90	2·250	3·68
Akhari	10·1	7·6	0·20	9·42	3·050	4·30

Moisture content.—The plants grow in drier situations and they do not tolerate water-logging.

pH—The plants grow in alkaline soils (pH 7·2–8·0).

Carbonate content.—The carbonate content ranges from 0·20 to 1·93 per cent.

Exchangeable calcium.—The plants are found to thrive in calcareous as well as non-calcareous soil. A range of 6·48 to 29·50 m.e. per cent. has been obtained for this factor.

Nitrate content.—The plants thrive in nitrogen rich as well as nitrogen poor soils (2·25 to 6·25 mg./100 g. of soil).

Organic matter.—A range of 3·68 to 5·30 per cent. has been obtained for this factor. Mall and Arzare (1956) found that this species grows at Sagar in soils with as high as 15·99 per cent. of organic matter.

PERFORMANCE OF THE PLANT IN DIFFERENT LOCALITIES

The data regarding the performance of the plant in different localities are given in Table V.

TABLE V

Performance of *A. aspera* in six different localities from Varanasi District.

Locality	Ht. of plant (cm.)	Length of spike (cm.)	Av. No. of spikes per cent	Av. No. of seeds per spike	Seed output
Rajghat	113·0	33·4	47	82	3854
Latifshaw	82·3	18·6	18	58	1044
Ramnagar	93·3	19·6	12	68	816
Lanka	125·0	36·2	40	80	3440
Sarnath	127·0	36·0	20	73	1460
Akhari	83·0	16·0	16	59	944

No definite correlation could be established between the soil analysis data and the performance of the plants. It is, however, to be noted from Table V that the length of the spike is a very variable feature (16·0 to 36·2 cm.).

ASSOCIATES

The associates of *A. aspera* in different localities are given in Table VI. The various notations used are: d=dominant, v.f=very frequent, f=frequent, v.a =very abundant, a=abundant, l.a=locally abundant, o.f=occasionally found, r=rare, –=absent.

TABLE VI

Associates of *A. aspera* in various localities situated in Varanasi District.

Species	Localities*					
	1	2	3	4	5	6
Achyranthes aspera	f	f	f	v.a	f	f
Aerua scandens	–	f	–	–	–	–
Amaranthus spinosus	–	–	–	–	–	f
Anesomeles ovata	–	–	f	–	v.a	–
Apluda mutica	–	a	–	–	–	–
Boerhaavia diffusa	–	–	–	–	o.f	–
Cassia occidentalis	–	r	–	o.f	–	–
C. tora	d	v.f	–	v.f	v.f	–
Corchorus acutangulus	r	–	–	–	–	–
Crotalaria medicagenia	a	f	r	f	–	–
Dactyloctenium aegyptium	r	–	–	o.f	–	–
Digitaria longiflora	–	–	o.f	–	r	–
Dichanthium annulatum	–	–	–	–	o.f	–
Eleusine indica	–	–	–	–	–	f
Eragrostis tenella	v.f	–	f	–	o.f	–
Euphorbia hirta	–	r	f	f	–	–
Justicia simplex	o.f	o.f	f	o.f	–	–
J. quinqueangularis	–	–	r	–	–	–
Linaria ramosissima	–	l.a	–	–	–	–
Peristrophe bicalyculata	a	v.f	f	f	o.f	–
Rhynchosia minima	–	–	f	–	–	–
Sida acuta	–	–	f	–	–	–
S. rhombifolia	–	r	–	r	–	–
Triumfetta neglecta	–	r	a	o.f	–	–
Urena lobta	–	–	o.f	–	–	–

*Localities: 1. Rajghat 2. Latifshaw 3. Ramnagar 4. Lanka 5. Sarnath 6. Akhari

BIOTIC FACTORS

A comparative study of Tables IV and V shows that in localities where *A. aspera* grows in association with *Cassia tora*, the former exhibits good growth and high seed output. Mall and Arzare (1956) have accounted for this, at Sagar, as due to the protection offered to the former, in such areas, against exposure and grazing. In areas where the grazing animals freely operate, plants exhibit poor growth and poor seed output.

The following fungal parasites are recorded on this species from India :

1. *Albugo bliti*—on leaves (Butler and Bisby, 1931).
2. *Cercospora achyranthes**—on leaves.
3. *C. achyranthina*—on leaves (Index of Fungi C. M. I., Vol. I, Pt. 18, 1949).
4. *Physalospora achyranthis*—on leaves and stems (Index of Fungi, C. M. I., Vol. I, Pt. 19, 1949).
5. *Ramularia* sp.*—on leaves.
6. *Septoria achyranthis*—on leaves (Index of Fungi, C. M. I., Vol. II. Pt. 9, 1954).
7. *Vestergrenia achyranthis**

DISCUSSION

Achyranthes aspera Linn. grows best in *Cassia tora* communities and this has been accounted as due to the protection given to it against exposure and grazing, an observation also made by Mall and Arzare (1956). *A. aspera* is indifferent to exchangeable calcium in the soil.

The seeds have a dormancy period of 2½ to 3 months. In the case of fresh seeds only 4 per cent. germination was obtained even which was partial. The radicle protruded out but its further elongation and growth did not take place. This may be due to the low temperature available during the winter months.

Stomatal frequency has been found to be higher in 'sun' leaves than in 'shade' leaves. Similar observations have been made in *Eclipta alba* (Ramakrishnan, 1960*a*) and this has been accounted as due to the drier conditions in the open than in shade, as pointed out by Salisbury (1932).

SUMMARY

1. This paper deals with the ecology of *Achyranthes aspera* Linn., a common weed in Varanasi District.

2. The soil analysis data do not give any clue to the preference of any type of soil.

3. The length of the spike has been found to be a very variable character.

4. The plants thrive very well in association with *Cassia tora* and this has been explained as due to the protection given to the former in such areas against exposure and grazing.

*This information was obtained from the Head of the division of Mycology and Plant Pathology Indian Agricultural Research Institute, New Delhi.

5. Majority of the seeds have a complete dormancy period of $2\frac{1}{2}$ to 3 months. A few of the fresh seeds germinate, but the radicle just came out, and further growth does not take place. This is perhaps due to the lower temperature in winter months.

6. The reproductive capacity, stomatal frequency of 'sun' and 'shade' leaves osmotic pressure of the plant sap, seedling morphology, etc., have been recorded.

ACKNOWLEDGEMENTS

The author is grateful to Professor R. Misra, Head of the Botany Department Banaras Hindu University for his interest in this work.

REFERENCES

Butler, E. J. and Bisby, G. R. 1934. *The Fungi of India. Sci Monog.* No. 1, I. C. A. R., Govt. of India Centl. Pub., Calcutta.

Hooker, J. D. 1872–1897. *The Flora of British India* (7 vols.). L. Reeve and Co., London.

Loomis, W. E. and Shull, C. A. 1937. *Methods in Plant Physiology.* McGraw-Hill Book Co., Inc., New York.

Mall, L. P. and Arzare, K. G. 1956. Autecological study of *Achyranthes aspera* Linn. *Bull. Bot. Soc., Univ. Saugar*, **8** : 69–76.

Misra, R. and Ramakrishnan, P. S. 1960. Ecological distribution of *Peristrophe bicalyculata* Nees. *Proc. nat. Inst. Sci.* (India), **26B** : 51–63.

Ramakrishnan, P. S. 1960*a*. Ecology of *Eclipta alba* Hassk. *Ibid.*, **26B** : 191–204.

——— 1960*b*. Ecology of *Echinochloa colonum* Linn. *Proc. Ind. Acad. Sci.*, **53** : 73–90.

——— 1960*c*. Studies in the autecology of *Euphorbia hirta* Linn. *J. Indian bot. Soc.*, **39** : 455–473.

——— 1961*a*. Calcicole and calcifuge problem in *Euphorbia thymifolia* Linn. *J. Indian bot. Soc.*, **40** : 66–81.

——— 1961*b*. Studies in the ecological life history of *Euphorbia thymifolia* Linn. *Proc. nat. Inst. Sci.* (India), **27** : 347–358.

Ridley, 1930. *The Dispersal of Plants throughout the World.* L. Reeve and Co., Ltd., Ashford, Kent.

Salisbury, E. J. 1932. The interrelations of soil, climate and organism and the use of stomatal frequency as an integrating index of the water relations of the plant. *Beih. Bot. Zbl.*, **49** : 408–420.

——— 1942. *The Reproductive capacity of Plants.* Bell and Sons, London.

CHROMOSOME NUMBERS AND HABITATS WITH SPECIAL REFERENCE TO TROPICAL PLANTS

By

R. P. PATIL *and* KRISHNA GHOSH

Central Botanical Laboratory, Allahabad

When in a species groups differ genetically and are adapted to different habitats, they are called "ecotypes" (Turesson 1922). Differentiation into ecotypes is much more likely to be found in common, widespread species than in rare, local or endemic ones (Turesson 1936). The habitat environment sorts out from among the constituents of a population those genotypes which are best fitted to survive and thus ecotypes arise (Gregor 1944). Sometimes, genetic isolation may put a stop to crossing and then the separated ecotypic groups will have the makings of a new species (Darlington 1956).

The genetic variation producing ecotypes may be at the visible chromosome level or merely at the genic level without any visible chromosome change. Where visible chromosome change is of the nature of differences in chromosome number the selection of the chromosome types by different external conditions can easily be studied.

Some instances of change in chromosome number in relation to habitat are discussed below. Such discussions are only of value when treating of species groups containing polyploids which are suspected on good evidence of being derived directly from the diploid species with which they are compared (Stebbins 1950).

As the grass *Poa alpina* climbs the Tatra mountains in Poland, it gains in chromosome number (Skalinska 1951). The diploid number is prevailingly 22 at the height of 500–1100 m. and the *2n* number is prevailingly 33–35 at 1800 m. and higher. The lowest number recorded in this species is 2n = 14. In this plant the higher chromosome numbers at the upper altitudes may be accounted for by the greater effectiveness of vegetative reproduction at these altitudes.

In India an instructive example is provided by the aquatic *Ottelia alismoides*. Here the hexaploids (2n = 66) show gigantism as compared with diploids (2n = 22) and when diploids and hexaploids occur together in the same pond, the diploids are marginal and the polyploids are in deep water (Sundar Rao 1951).

It is studies on the geographical-cum-habitat distribution that have yielded some very interesting data. In *Biscutella laevigata* (Cruciferae), the diploids (2n = 18) are found in the plains of Europe, the tetraploids have invaded the Alps and a hexaploid is found on "Picos de Europa", the highest mountains of Spain (Manton 1937).

The distribution in the U. S. A. of *Cuthbertia graminea*, a xeric sandhill species is of some significance (Giles 1942). The diploids (2n = 12) occupy a very restricted area in southern North Carolina that is geologically old (Cretaceous). The coastal area occupied by the tetraploids is much larger, extends principally to the east and south, and is geologically young (Pleistocene), being newly arisen as the sea retreated.

There is some evidence from the above examples that the polyploids occur at the colonising margin of the species or genus, where, so to say, new habitats are presented to the expanding species.

Coming to the tropics of India, an interesting example is found in *Nymphaea stellata*. In Kerala, this species is diploid (2n=28) but in the geologically younger Gangetic Plain it occurs only as a hexaploid (Janaki Ammal 1959). *Ottelia alismoides* has been reported to have diploid, tetraploid and hexaploid races with a basic number of 11 (Sundar Rao 1951). A study of their distribution shows that S. India (the centre of origin) has diploids, tetraploids and hexaploids, but only polyploids are present in N. India including the Gangetic Plains.

The existence of several chromosome races has also been demonstrated in *Scilla indica* (Liliaceae) by Sundar Rao (1956). Besides diploids (2n=30), triploids (2n=45) and tetraploids (2n=60) there exist aneuploids with 2n=44, 46 and 58. The diploids occur towards the west coast (Bombay, Dharwar and Mysore), the triploids on the east coast (Masulipatam to Madras) and the tetraploids in Madhya Pradesh. The aneuploids coexist with their triploid and tetraploid relatives and nowhere else. Whilst this distribution cannot be satisfactorily explained with the available data, it is certainly significant that the various chromosome races have characteristic differences in their geographic distributions. It may be noted that the triploids differ from the diploids and the tetraploids in this species by their linear-lanceolate leaves and the presence of bulbils on the leaf tips.

Stebbins (1938) concluded that the highest percentage of polyploids is to be found in perennial herbs, while annual and woody plants have lower percentages of polyploidy. Higher percentages of polyploidy are therefore to be expected in floras containing a great preponderance of herbaceous perennial species, as is the case in most cool temperate and subarctic floras.

While herbaceous perennials are not a strong element in the natural flora of the humid tropics, man by extensive clearing of the forests has created open habitats which have been invaded by pioneering herbaceous perennials. The most important of these in the tropics are the grasses. *Heteropogon contortus*, *Cynodon dactylon* and *Sorghum halepense* which are common in the Gangetic Plains, are distributed all over the tropics and the warm temperate regions of the world. Others like *Themeda triandra* have extensive distributions (Africa, Indo-Malaya, Australia). It is not surprising that such grasses have ecotypes with varying chromosome numbers. Thus the diploid numbers of 20, 44, and 60 have been reported in *Heteropogon contortus* (Darlington and Wylie 1955). In *Cynodon dactylon* the diploid numbers of 36 and 40 are known and in *Sorghum halepense* 20 and 40 have been reported as diploid numbers (Darlington and Wylie 1955). It would not be surprising if additional numbers are reported in the above species when intensive cytological studies are undertaken with reference to habitats. In *Themeda triandra* diploid numbers of 20, 22, 30, 40, 45, 49, 50, 51, 53, 54, 56, 60, 68 and 71 have been reported in Africa (Pienaar 1955) and in India at least two chromosome races have been reported, *viz.* 2n=20 and 2n=80 (Raman *et al* 1959). An octoploid Indian strain with distinct phenotype has been reported in *Chrysopogon montanus* (Mehra 1955*a*). An intensive study of *Saccharum spontaneum* has shown that the Lahore and the Dehra Dun forms have n=27, Bihar types have n=28, 30, 32 and 36, the Assam form has n=40, the Burma form has n=48, and the Sumatra and Java forms have n=50 and 56 (Parthasarathy and Subba Rao 1946). Recent observations at the Central Botanical Laboratory by the present authors have shown that the Allahabad *Dichanthium annulatum* has n=10 as reported earlier by Mehra (1955*b*). Only the tetraploid form (2n=40) of this species has been reported by Darlington and Wylie (1955).

Tischler (1937) found a high percentage (65 %) of polyploids in the halophytic flora of certain islands in the North Sea. With a view to finding out if such observations hold good for saline habitats in India, a survey is being undertaken at the Central Botanical Laboratory and Sidhu (1961) has reported that *Suaeda monoica* which has a restricted distribution on the East Coast (southwards from the Kistna River) is a diploid (n=9) whereas *Suaeda nudiflora* which has a more extensive distribution (southwards from Chilka Lake) is a tetraploid (n = 18).

ACKNOWLEDGMENT

The authors wish to thank the Chief Botanist, Botanical Survey of India and Dr. G. S. Puri, Director, Central Botanical Laboratory, for their kind interest and facilities offered for the preparation of this paper.

REFERENCES

Darlington, C. D. 1956. *Chromosome Botany*, London.

——— and Wylie, A. P. 1955. *Chromosome Atlas of Flowering Plants*, London.

Giles, N. H. 1942. Autopolyploidy and geographical distribution in *Cuthbertia graminea* Small. *Amer. Jour. Bot.* **29** : 637–645.

Gregor, J. W. 1944. The ecotype. *Biol. Rev.* **19** : 20–30.

Janaki Ammal, E. K. 1959. Cyto-geography of some Indian plants. *Curr. Sci.* **28** : 55.

Manton, I. 1937. The problem of *Biscutella laevigata* L. II. The evidence from meiosis. *Ann. Bot. Lond.* n. s. **1** : 439–462.

Mehra, K. L. 1955 *a*. Chromosome races in *Chrysopogon montanus*. *Curr. Sci.* **24** : 95–96.

——— 1955 *b*. Chromosome numbers in the tribe Andropogoneae, Gramineae. *Indian J. Genet. Pl. Breed.* **15** : 144.

Parthasarathy, N. and Subba Rao, K. S. 1946. Chromosome survey of *Saccharum spontaneum* L. *Indian J. Genet. Pl. Breed.* **6** : 5–10.

Pienaar, R. de V. 1955. *South African Grasses and Pastures*, Part 2, Central News Agency Ltd., South Africa.

Raman, V. S. Chandrasekharan, P. and Krishnaswami, D 1959. Note on some chromosome numbers in Gramineae. *Curr. Sci.* **28** : 127–28.

Sidhu, S. S. 1961. Chromosomal studies of some mangroves. *Proc. 48th Ind. Sci. Congr.* Part 3, 302–303.

Skalinska, M. 1951. Cyto-ecological studies in *Poa alpina* L. var *vivipara* L. *Bull. Acad. Pol.* Ser. B (1) 253–283.

Stebbins, G. L. 1938. Cytological characteristics associated with the different growth habits in the dicotyledons. *Amer. Jour. Bot.* **25** : 189–98.

——— 1950. *Variation and evolution in plants*, New York.

Sundar Rao, Y. 1951. Cytological studies in *Ottelia*. *Curr. Sci.* **20** : 72.

——— 1956. *Scilla indica* in India. *Curr. Sci.* **25** : 164–165.

Tischler, G. 1937. Die halligen Flora der Nordsee im Lichte cytologischer Forschung. *Cytologia*, Fujii Jubil. **Vol.** : 162–169.

Turesson, G. 1922. The species and the variety as ecological units. *Hereditas*, **3** : 100–113.

——— 1936. Rassenokölogie und Pflanzengeographie. *Bot. Not.* 420.

DISCUSSION

Mrs. S. Vaidya : Has any experimental transplantation of ecotypes been carried out with a view to testing the relationship between habitat and chromosome status ?

Dr. R. P. Patil : Not in India.

ECOLOGICAL PROBLEMS IN THE WESTERN HIMALAYAS

By

J. S. SINGH *and* M. K. WALI*

Central Botanical Laboratory, Calcutta

The Western Himalayas have been recognised as a distinct botanical region by Chatterjee (1939) and Puri (1960), comprising of Himalayan mountains from Kumaon to Kashmir. The entire area is hilly to mountanous and has a rugged topography, extending from about 303 m. above sea level (Siwaliks) to about 8181 m. (Nanga Parbat). Western Himalayas form a narrow angular belt between approximately 29° to 36°N latitudes and 72°·7′ to 81°E longitudes.

Geologically Western Himalayas have been divided into three distinct entities, *viz.*, outer, middle and inner Himalayas (Wadia 1916).

Ecological Problems :

The following important problems that need special attention of the ecologists and foresters interested in the ecology of the Western Himalayas have been selected :

(1) the study of forest types and undergrowth in relation to climate, geology and soil,

(2) successional studies in different forest types,

(3) autecological studies of some important species,

(4) studies on the natural regeneration of forest trees,

(5) ecology of erosion, landslips, afforestation, proper land use and flood control,

(6) ecological relationship of agriculture, grasslands and forests with particular reference to fire, grazing and other human interferences,

(7) the effect of the introduction of exotic plants on the natural vegetation, and

(8) general ecological survey of forest growth and forest soils with particular reference to raising plantations of valuable endemic species and regeneration of desired species in place of existing uneconomical and inferior ones.

The study of the forest types and successional trends of various communities will greatly help in the determination and confirmation of climatic climax of the area. The climax vegetation of an area is usually the best to check soil erosion (Lutz and Chandler 1946). Knowledge of successional trends of forest vegetation could be of great practical value in determining the species for afforestation and reclamation of land.

Autecological studies of the important trees, attain great significance as they help in understanding the environmental and nutritional requirements of the given species. This would greatly help in selecting suitable species for afforestation in a particular area. Extensive experimental studies on the regeneration of important trees like silver fir, spruce and deodar are also required.

*Present address ; S. P. College, Srinagar.

The problem of soil erosion is as acute as ever. In order to check it we need an extensive survey for the accomplishment of planting suitable species, for we know that afforestation of an area can greatly reduce the extent of erosion (Singh and Wali 1962). We also need a check on excessive felling and cutting of trees. Besides the natural factors affecting erosion such as surface geology, formation of rocks, excessive rainfall, etc., the indiscriminate felling of forests, the socio-economic conditions of the hilly tribesmen and grazing are the important factors responsible for the initiation and stimulation of soil erosion. These factors along with the methods to check soil erosion in the Himalayas have been discussed some where else (Singh and Wali 1962).

Another problem of great significance is the study of mineral circulation in the forest ecosystem. It is known that minerals absorbed from soils by trees are returned in a good proportion to the soil by way of litter fall and death and decay of root system. The decomposition of litter to form humus and release minerals in available form is governed by many factors like type of vegetation, soil conditions, and environmental conditions like temperature and light.

It has been stated that in a normal developing forest the decomposition of organic debris must keep pace with the addition of fresh material from the forest vegetation. If the first process becomes slower than the second, incompletely decomposed residues are accumulated at the surface of the soil, hindering the growth and regeneration of species. This incompletely decomposed residue forms a thick mat on the soil surface under pure conifer communities while in mixed broad leaved-conifer communities the decomposition appears to be quicker. Quantitative studies on the humus status under different forest communities of Bashahr Himalayas support the above view (Singh 1962).

The data collected by Singh (1962) shows that the ratio of total fresh litter/unincorporated humus and the humus content of surface soil are highest under *Quercus semecarpifolia* community. This may show the higher speed of litter decomposition under this community than under pure coniferous ones. The ratio of leaf/twig amongst fresh litter is also highest under *Quercus semecarpifolia* community. The presence of broad-leaved species like *Quercus semecarpifolia* and *Rhododendron arboreum* and the abundance of shrubs of *Indigofera gerardiana* and *Rosa macrophylla* in conifer communities seems to favour the decomposition of coniferous litter.

Singh (1962) has also discussed the factors possibly responsible for the slowness in decomposition of litter causing, thereby, accumulation of the unincorporated humus under coniferous communities of Bashahr Himalayas. It has also been found that mineral status of soils has got a profound influence on the rate of decomposition. Waksman (1938) and Lutz and Chandler (1946) have shown that the decomposition of plant material is most rapid in soils rich in calcium. This has been confirmed by Puri and Gupta (1951). Thus detailed analysis of the soils of the whole area is extremely necessary. Among the environmental factors, light and temperature of the soil surface, micro fauna and flora inhabiting the soil layers are most important to be sudied.

ACKNOWLEDGMENTS

The authors wish to express their thanks to the Chief Botanist, Botanical Survey of India and Dr. G. S. Puri, the then Director, Central Botanical Laboratory for the facilities and encouragement.

REFERENCES

Chatterjee, D. 1939. Studies on the endemic flora of India and Burma. *Jour. Roy. As. Soc. Bengal Sci.*, **5** : 19–67.

Lutz, H. J. and Chandler, R. F. 1946. *Forest soils.* John Wiley & Sons, Inc., N. Y.

Puri, G. S. 1960. *Indian Forest Ecology.* Oxford Printing Press, New Delhi.

——— and Gupta, A. C. 1951. Himalayan Conifers II. The ecology of humus in conifer forests of Kulu Himalayas. *Indian For.*, **77** : 55–63 ; 124–129.

Singh, J. S. 1962. Preliminary studies on the Humus status of some forest communities of Bashahr Himalayas. *Proc. Nat. Acad. Sci., India, Sec. B*, **32** : 403–407.

——— and Wali, M. K. 1962. The problem of soil erosion in some parts of Kashmir Himalayas. *Pro. Nat. Acad. Sci. India, Sec. B*, **32** : 118–124.

Wadia, D. N. 1916. *Geology of India.* McMillan & Co., London & Calcutta.

Waksman, S. A. 1938. *Humus—origin, chemical composition and importance in nature.* Williams & Williams Co., London.

INVASION OF PLANTS IN ARID REGIONS OF INDIA

By

S. K. JAIN

Botanical Survey of India, Calcutta

The states of Rajasthan, Gujrat and parts of Maharashtra, Punjab and Mysore constitute the arid and semiarid regions of India. These are characterised by low and uncertain rainfall, high temperature and low humidity in summer. In addition these areas have, during the past several centuries, suffered considerably from adverse biotic interference, resulting in the destruction of vegetation and the increase of arid conditions.

These areas were not arid about twentyfive centuries ago and a good cover of vegetation and civilization existed there. Due to various climatic, biotic and political factors the rich and dense mesophytic flora gradually dwindled giving way to xerophytic elements. The flora which could thrive under intense browsing by sheep and camel established in the area.

These desert conditions have been accentuated by man through destruction of forests for fuel and land for cultivation.

Pramanik *et al* (1952) have shown that there has been no appreciable change in the rainfall, temperature, humidity and wind velocity during the last 70 to 80 years over Rajasthan and adjoining areas. Also the extent of the desert has not increased on any large scale.

However, due to destruction of tree vegetation, the habitat has been constantly depauperated by rendering the soil poorer in humus and moisture content. The paucity of higher vegetation in adjacent areas and consequent lower supply of seed material for regeneration might also have contributed to the degradation of vegetation.

Our knowledge of the flora of the arid and semiarid regions of India is very recent, chiefly due to the efforts of Sarup (1954), Biswas and Rao (1953), Nair (1959), Joshi (1958), Puri and Jain (1959 a, b), Jain (1960 a, b) and Santapau (1962) who, during the last ten years, have published list of plants of these regions. One fact has been brought out by all these workers that due to the constant pressure on vegetation of biotic interference xerophytic and hardy species alone are able to establish and spread in these regions.

In the following discussion some plants which have been recently recorded from the arid regions in India are cited.

Dipterygium is a small genus of three species distributed in Egypt, Arabia and Western Pakistan. The species *Dipterygium glaucum* Decne. has now been found to be common on unstabilised hot sand in Rajasthan (Jain, 1960).

Astragalus prolixus Sieb. is an Egyptian plant reported earlier only from Sind. It is now common in Kutch in saline soil near sea-coast.

Cassia angustifolia Vahl is a shrub native of tropical Africa, also reported from Arabia. It has recently been found growing wild commonly in Kutch.

Heliotropium calcareum Stocks is a small plant with woody base. It was known earlier only from Sind, but has now been found to be common in coastal areas of Kutch.

Premna resinosa Schau. is a plant first named from Africa. It has been found to be abundant in Kutch. It is now rather the most dominant shrub in the undergrowth at Dhinodhar, Khadwa and Kaladungar areas, (Deshpande, 1961).

Asparagus dumosus Baker is a bushy undershrub. Cooke (1908) reported this plant as endemic to Sind. It seems to have recently invaded western parts of India. Santapau (1953) reported it from Saurashtra. It was found to be one of the commonest plants along sandy coasts of Kutch (Jain and Kanodia, 1960).

Juncus maritimus Lamk. occurs in Australia, North and South America, Sind and Afghanistan. Good (1953) remarked about this species '*Juncus maritimus* ranges over Europe and parts of Africa and again in Australia and New Zealand.' Good did not, obviously, record its occurrence in Asia. This plant has recently been collected on two occasions from Kutch growing in saline soil forming dense colonies in dried saline lowland or stagnant waters (Jain, 1960).

Dignathia hirtella Stapf has been collected by the author from Dhinodhar in Kutch. It had not so far been reported from India (Raizada and Jain, 1961).

Tripogon roxburghianus Bhide was known only from drier parts of Bombay State but has now been found to extend as far north as Kailana near Jodhpur (Jain and Kotwal, 1960).

Crypsis schoenoides Lamk. is a small grass not known so far from Rajasthan and Kutch but recently found to occur in a dried pond at Bap near Jaisalmer in northwestern Rajasthan.

Chrysopogon aucheri Stapf was known only from Sind and has now been found growing in the interior hilly regions of Kutch at Dhinodhar.

Although the climatic data of last 70 to 80 years do not reveal any trend of decrease of rainfall or increase in temperature, yet, there is no doubt about the increasing biotic pressure in the aforementioned areas of India. The vegetation of these arid tracts is being destroyed on a larger scale causing denudation of vegetation cover and exposition of soil and sand. The original natural flora of these areas is being gradually eliminated. The xerophytic and halophytic species as described above become pioneers to land in these modified habitats, they establish and spread.

Further intensive botanical exploration of the arid and semiarid regions of India is bound to reveal more and more of such elements in the flora. It will be interesting to study the autecology of the species which are now establishing and spreading in the arid regions *vis-a vis* species which are gradually disappearing.

With the establishment of the Central Arid Zone Research Institute at Jodhpur and the Arid Zone Unit of the Botanical Survey of India at Allahabad precise information on botany and ecology of the arid regions of India can now soon be expected.

ACKNOWLEDGEMENT

I am grateful to the Chief Botanist, Botanical Survey of India for kindly granting facilities for this study as well as for participation in the symposium at Allahabad.

growing on uplands also shows a higher mineral content but the soils of the area are comparatively poor. Since *Cymbopogon--Saccharum* commnnity is kept protected from grazing, the occurrence of *Cymbopogon martinii* appears to be probably more due to protection from grazing than soil mineral contents. *Satcharum munja* shows the lowest foliar mineral content growing in soils with medium amount of minerals. On the basis of these observations the species may be classfied as given in Table 1.

TABLE 1

Showing the specific preferences of each grass to soil condition and grazing intensity, (April, 1960)

Plant species	Habitat condition	Soil cation status	Soil moisturc	Mineral status	Degree of grazing
Imperata cylindrica	Moist region	High	High	High	Moderate to intense
Vetiveria zizanoides	do.	do.	Highest	do.	do.
Saccharum munja	Lowland	Medium	Medium	Lowest	Moderate
Cymbopogon martinii	Upland	Lowest	Lowest	Medium	Protected
Saccharum spontaneum	do.	do.	do.	do.	do.

ACKNOWLEDGEMENT

The author is greateful to the Chief Botanist Botanical Survey of India for the facilities provided and to Dr. G. S. Puri for guidance and encouragement through out the work.

SOIL-VEGETATION RELATIONSHIPS IN CENTRAL INDIA

By

S. C. PANDEYA

Central Botanical Laboratory, Allahabad

A good deal of work has been done on agricultural soils (Raychaudhuri and others, 1959), detailed studies of forests and grasslands soils have not been done in this country. Nevertheless, some literature on forest soils of Madhya Pradesh is avilable from (Puri 1953, Bhatia 1954, Jain 1960, Joshi 1960, Pandeya and Jain 1961).

On the basis of available data on soils of Madhya Pradesh, the author has made an attempt to discuss the soil-vegetation relationships.

A number of workers have reported correlations between certain edaphic factors and the vegetation. This fact does not necessarily indicate, as pointed out by Moore (1959), that edaphic factors alone are primarily responsible for the occurrence of a particular community at a particular site. It is in this direction that the necessity of considering the 'whole' environment, and of considering each factor of the environment in relation to all the others has been stressed by Cain (1944) and Billings (1952). Moore (1959) further points out that in view of the complexity of the factors involved, it is not surprising that relatively little experimental work has been attempted to determine the environmental factors associated with particular plant communities, or to determine the tolerance limits of individual species.

Sal (*Shorea robusta*) forests have been found to grow on all rock types in the state. The incidence of the species and the proportion and kind of associate species do vary. The soils under sal forests have been found to be similar under certain limits. Minor differences do occur in soils under same rock type but under different sal forest communities or sal quality class.

Both Puri (1952, 53, 54, 55 and 57) and Khan (1953) reported sal forest soils as poor in calcium, derived from acidic rocks, giving on the whole an acidic reaction between pH ·4 – 7·0. Sathe (1951), however, could not correlate calcium content of rocks and sal growth. The finding has been confirmed by Hewetson (1953). Thus sal attains first quality at Machkot (Jagdalpur), when the underlying rock is cuddapah limestone and shales. However, the soils remain base deficient.

A comprehensive study of sal soils of the state has been made by Puri (1953), Jain (1960) and Pandeya and Jain (1961). The studies are in essential confirmation. The soil characters have been confirmed by foliar analysis. With the help of superficial soils and profiles studies Jain (1960) has concluded that sal soils can be classified into three types, *viz.* those under best sal forests, under medium growth and lastly those under poor sal growth. The first type of soils are generally leached down, with pH between 5·5 to 6·5, lower exchangeable calcium (between 0·05 to 0·1%), with slightly more of total nitrogen (0·004 to 0·03%) and with more of iron. The soils are sandy loam having sand between 50 to 60%.

Soils under medium sal growth appear to be immature and somewhat richer in bases. They have higher pH, and less of exchangeable iron. Soils under poor sal growth are fresh and sandy. Sand is above 70%. They are again poor in bases and with lower pH. Further, soils under sal develop into red or blackish sandy loam, irrespective of underlying rock. Dealing with the calcium relations

of sal Jain (1960*a*) has concluded that exchangeable calcium increases in soils from sal class I to II followed by a subsequent decrease in other classes.

Similarly, comparing the soils under Teak forests it is seen that they are almost neutral and are not base deficient ones. This is again irrespective of the underlying rocks.

Puri (1960) describes Teak forests to occur on basaltic hills and riverain alluvia at many places south of Vindhyas. Bhatia (1954) has studied the detail chemical composition of Teak soils in forests of Madhya Pradesh. He has demonstrated that incidence of the species depended upon a minimum level of exchangeable calcium in the soil whatever be its origin. Thus it was shown that many of the acidic soils bearing good teak growth contained more than 0·39% of exchangeable calcium. However, at Allapali (south Chanda division), with C. P. Best Teak, the substrata is base poor (soils derived from granite, gneissus and quartzites). Bhatia has shown an equally important role of phosphorus in teak soils, which is as much as 1% in trap rocks. However, Misra (1957) has emphasized that this matter needs further investigations.

Joshi (1960) has made a comparative study of soils under three types of forests. According to him soil profiles under teak forests are almost neutral, immature, and rich in bases.

Mixed forest soil profiles have been observed by Joshi (1960) to be fresh to immature. They are neutral to alkaline with varying amounts of calcium depending upon the parent rocks.

Thus it was shown by Dubey (1958) that soils of Jabalpur are all fresh to immature. Jabalpur presents a series of lithological features supporting mixed forests under the existing biota. With the help of profile studies, Dubey (1958) has observed that all the profiles on different rocks are different in chemical charcters. The soils on sandstones, basalt (red soils) and granite, have low percentage of exhangeable calcium and higher percentage of sesquioxides. The pH is neutral to acidic. Basalt black cotton soils are basic and base rich. Alluvial soils of Jabalpur are basic with high percentage of exchangeable calcium. Dubey has concluded that the soil characters maintain much of the parental characters when it is freshly formed.

A study of the soil physical characters of Jabalpur profiles on different rock types, as described above, has been made by Pandeya and Awasthi (1959). During August/September, 1957, the highest moisture content and water holding capacity were observed in basalt black cotton soil, being 31·67 to 34·05% and 54·95 to 38·55%, respectively. The maximum sand percentage was recorded in granite soils (39·1 to 50·2%). Clay was highest in calcareous clays, being 54·4 to 88·1%. The second higher was in basalt black soil and alluvium (66·06 to 80·1 and 69·45 to 76 6%, respectively). The maximum pore space was found in sandstone soils (54·03%). The next near figures were in granite (43·58%) and laterite (43·08%) soils.

A inter-comparison of soils under different types and different rock types may assess the importance of vegetation in deciding the characters of the soil.

Factorial approach :

In this connection it is observed that factorial approach, as mathematically shown by Jenny (1941) and Jenny and Raychaudhuri (1960) is of great value. Jenny (1941) considers two sets of soil forming factors, *viz.*, independent variables and dependent variables. He considers that soil properties are the function of independent variables like climate, organisms (both plant and animals), topography,

parent material and time. Soil is, therefore, a dependent variable which has been formed in a long period of time. It is obvious that soil features will be correlated with any of the soil forming factor to a certain extent. The extent, in turn, may be governed by the limiting factor. Thus, if the soils are fresh, as is mixed forests, the soil properties are largely governed by the characters of the parent rock; 'time' being a limiting factor here. In most of the regions of the state biotic operations keep the status of the vegetation and subsequently that of soils. Soils of these regions are mostly fresh coarse, *e.g.*, Jabalpur soils. In some such places even with withdrawal of lessening of biotic factor, the progress of vegetation is very slow and not readily recognisable. The climate, as pointed out by Richards (1961), becomes limiting. This is because the microclimate gets vastly changed due to removal of vegetation. Effect of climate as a limiting factor on "edaphic formations" has been repeatedly pointed out by Van Steenis (1958), Richards (1961) and Jenny and Raychaudhuri (1960).

In conclusion, it may be said that soil is the function of its environment, and the soil properties are largely governed by a set of independent soil forming factors, and that no factor can be singled out as the master factor. Since soil properties are the function of multifactors 'low of limiting factor' can also be applied in gauzing the soils.

ACKNOWLEDGEMENTS

The present paper is a result of combined discussions with my students, especially Mr. N. K. Jain and Mr. S. R. Joshi, to whom I am much thankful. I am also very much thankful to Dr. G. S. Puri, Director Central Botanical Laboratory Allahabad, and Prof. R. Misra, Head of Botany Dept. Banaras Hindu University, Varanasi, for valuable suggestions and constant encouragement.

REFERENCES

Bhatia, K. K. 1954. Factors in the distribution of Teak (*Tecton a grandis*) and a study of Teak forests in Madhya Pradesh Doctoral Thesis, Saugar University.

Billings, W. D. 1952. The environmental complex in relation to plant growth and distribution. *Quart. Rev. Biol.* **27** : 25-1-265.

Cain, S. A. 1944. *Foundations of Plant Geography.* New York : Harper and Borther.

Dubey, M. D. 1958. Soil profiles of Jabalpur, M. Sc Thesis, Jabalpur Univ.

Gorham, E. 1955. Vegetation and the alignment of environmental factors. *Eco.* **36** : 514–515.

Hewetson, C. F. 1953. A discussion on the ecological position of Sal in Central India. *Indian For.* **79** : 310–320.

Jain, N. K. 1960. Ecology of sal in Madhya Pradesh. Doctoral Thesis, Jabalpur University.

——— 1960 *a*. Calcium relations of sal. *J. Indian bot. soc.* **39** : 357–372.

Jenny, H. 1941. *Factors of soil formation.* McGraw Hill Book Co., New York.

Jenny, H. and Raychaudhuri, S. P. 1960. *Effect of climate and cultivation on Nitrogen and organic matter Reserves in Indian soils.* Indian Council of Agri. Res., New Delhi. Job Printing Press, Kanpur.

Joshi, S. R. 1960. Autecology of *Anogeissus latifolia* Wall. Doctoral Thesis, Jabalpur University.

Khan, M. A. W. 1953. Effects of geological formation on the distribution of sal. *Indian For.* **2** : 462–474.

Misra, R. 1957. Ecological studies in Madhya Pradesh. *Presidential Address 27th Session, Nat. Acad. Sci., India (Biology Section).*

Moore, C. W. E. 1959. The Nutrient status of the soils of some natural plant communities on the southern tablelands of New South Wales. *Eco.* **40** : 337–349.

Pandeya, S. C. and Awasthi, S. N. 1959. The root systems of *Tephrosia purpurea* Pers. and *Acanthospermum hispidum* D. C. in different soil types of Jabalpur. *Proc. Nat. Acad. Sci. India. Biolg. Sci. Sect.* **29** : 346–35 .

Pandeya, S. C. and Jain, N. K. 1961. Soil and climatic factors in determining distributional patterns of forests in Madhya Pradesh with special reference to sal (*Shorea robusta*). *Memoir* 3. *Indian Bot. Soc. Symp. Pattern on Plant distribution.*

Puri, G. S. 1952. The amount of foliar ash in sal (*Shorea robusta*) trees of different classes in India. *J. Indian bot. soc.* **31** : 82–88.

——— 1953. Problems in the ecology of sal (*Shorea robusta*) in Madhya Pradesh. *Bull Bot. Soc. Univ. Saugar* **5** : 24–31.

——— 1954. Soil climate of some Indian forests. *J. Indian bot. soc.* **23** : 394–416.

——— 1955. The ecology of sal (*Shorea robusta*) in Madhya Pradesh. *Symp. 42nd Indian Sci. Congr. (Bot. Soc.) Baroda.*

——— 1957. Foliar ash and sal distribution in relation to soil. *Proc. Nnt. Acad. Sci. India. Biolog. Sci. Sect.* **27** : 16.

Raychaudhuri, P. S. 1959. Classification and nomenclature of Indian soils. *46th Session Indian Sci. Cong. (Agri. Sec.) symp. classifcation and nomenclature of Indian soils.*

Richards, P. W. 1953. *The Tropical Rain Forests.* Cambridge Press, Cambridge.

——— 1961. The types of vegetation of the humid tropics in relation to the soil. *Abidjan Symp. Tropical Soils and Vegetation. Humid Tropics Research. UNESCO Publica. Paris.*

Sathe, P. G. 1951. The role of geology in the distribution of sal and other plants communities in some forests of Madhya Pradesh. *Proc. 8th Silvic. Conf. Dehra Dun.*

Van Steenis, C. G. G. J. 1958. Discrimination of tropical shore vegetation, UNESCO symp. The vegetation of the humid tropics, Bogor.

PLANT INTRODUCTION IN THE ARID ZONES OF INDIA

By

R. N. KAUL, *Silviculturist*

and

B. N. GANGULI, *Assistant Silviculturist*

Central Arid Zone Research Institute, Jodhpur

PROSPECTS OF PLANT INTRODUCTION

One of the main objects of management in the arid zone is to hasten the pace of afforestation and to increase the productivity of land. The indigenous flora is characterized by stunted growth habit and meager variety. Parde has indicated the possibilities of judicious introduction of useful exotics in arid zones of the world where the CVP index ranges betwecn 100 to 300.

BASIS OF PLANT INTRODUCTION

In any sound scheme of plant introduction climate must be the principal consideration and the most suitable plants for any given climate are those occurring naturally in any reasonably similar climate.

In general plants thrive better in a relatively more equable climate which is at the same time comparable to that prevailing in their native habitat. Consequently when seeding or planting is done at the northern geographical range of a species, or when an exotic species are introduced from a warmer region, warm local situations on southern and western aspects should be selected. At the southern geographical range, or when an exotic species is introduced from a colder region, cool local situations should be selected on northern and eastern aspects where the air and the soil temperature is comparatively lower than that occurring or the sourthen and western aspects. The capacity of various tree species to endure high temperature is also very variable. As a rule, the capacity of a species to withstand a higher temperature above the optimum is not so great as for resisting cold. Also, the individuals of a species with a wide range of distribution exhibit varied tolerance to critical temperatures. For such species, it is not enough to know the general temperature requirements of the species as a whole because the success in seeding and planting, often depends upon the seed provenance. Selection of suitable ecotypes is therefore necessary. As a guiding principle, forest trees should not be seeded or planted in a region much colder than the area where the seed is collected even if the limit of distribution of the species is much further north. Transplantations from a warmer to a colder site is always unfavourable mainly due to susceptibility to early or late frosts, which are disastrous for forms having a shorter period of dormancy. Similarly planting in exceptionally warmer localities stimulate an initial rapid growth which upsets the physiological regime and metabolism of plant leading to ultimate exhaustion and death.

Acclimitization to a new environment occurs only when the climatic changes is not too great. The period during which acclimitization is achieved varies with the species, depending on its genetic plasticity and the degree of specilization. The principle of homoclimes, therefore, needs to be thoroughly appreciated

especially, in connection with endemic and anplanstic species, possessing more or less highly specialized attributes.

Mayer (1906) proposed the theory of climatic analogy as an explanation of the phenomenon of acclimitization, and his conclusions were supported by Pavari (1916). According to this theory the more similar the climatic conditions in original and new habitats, the more successful will be the adaptations. Therefore according to Mayer (1906) experimentation with an exotic must be preceeded by study of ecological conditions in both habitats, particularly with regard to average annual temperature, relative humidity and rainfall during the period of vegetative growth. Pavari (1916) stressed, in addition, the importance of mean temperature of coldest and hottest months.

Thus while the theory of climatic analogy may serve as a useful guiding principle in selection of species for introduction nevertheless the potential inherent plasticity of species belonging to a large number of genera which enables them to meet the demands of new conditions should not be overlooked.

SUGGESTED SPECIES FOR INTRODUCTION

Experience gained with the introduction of exotics in other parts of the world have revealed that the genera *Acacia, Agonis, Ailanthus, Amygdalus, Argania, Brachychiton, Callitris, Casuarina, Celtis, Ceratonea, Crataegus, Cupressus, Dodonea, Eucalyptus, Eremophila, Ficus, Geigera, Gravellia, Heterodendron, Myoporum, Owenia, Perkinsonia, Pittosporium, Retama, Schinus, Tamarix, Ziziphus*, etc., from isoclimatic regions of the world having definite usefulness as fuel, small timber, fodder, wind break and shelter belts can be introduced in the arid parts of India with reasonable hope of success.

PROGRESS OF ACCLIMITIZATION OF EXOTIC WOODY PLANTS IN ARID RAJASTHAN

The work on acclimitization of woody exotics started with the establishment of an arboretum in Jodhpur in the year 1958 where species from the isoclimatic regions of the world are being tested as regards their survival and growth performance. Out of the several genera tried so far, *Eucalyptus* and *Acacias* have shown promise for large scale introduction. Plant population and height growth studies indicated that *Eucalyptus camaldulensis, E. paniculata, E. rostrata E. melanophloia, E. tereticornis, E. crebra* and *E. longicornis* and *Acacias spirocarpa, A. gregii, A. ligulata* have great success in Arid Rajasthan. *A. spirocarpa* deserves a special mention in as much as that within 2½ years of its introduction it has attained an average height of 417 cms. and a diameter of 5 cms.

ACKNOWLEDGMENT

The authors are grateful to Dr. P. C. Raheja, Director and Shri C. P. Bhimaya, Head of Division of Resource Utilization for Providing facilities for the studies on phytoplasticity. Thanks are also due to Shri M. A. Waheed Khan, Ecologist, Forest Research Institute, for his valuable suggestions.

REFERENCES

Mayer, H. 1906. Fremadlandische Wald–Und Parkbaiisme Für Europa.

Parde, J. Wood production and Paterson's formula. *Journal Forester Suisse,* **110** : 211–21. (Translation from French by M. A. Waheed Khan).

Pavari, A. 1916. Studio preliminare Sulla Coltura di specie Forestali esotiche in Italia. *Aunali del R. 1st Sup. For. Nazionale. Firenze.*

Wilsie, C. P. and Shaw R. H. Crop Adaptation and climate Advances in Agronomy, **6** : 199–252.

PROBLEMS ON TROPICAL ECOLOGY

By

JOHN H. DAVIS

University of Florida, Gainsville, (U. S. A.)

Tropical regions, and particularly the tropical climate parts of India, Pakistan and Burma are very varied in respect to their lowland and upland topography, seasonal rainfall and temperature, soils and rocklands and surface and permanent water conditions. The basic ecological problems are to determine how the types of vegetatation, the wildlife and animal communites, and the human populations and their customs and enterprises are affected by these differences and the many combinations of their variables. This can be the objective of the whole scope of ecology, both the basic and applied aspects.

But there are much more pressing problems. These involve the human factor of use and control over the most altered regions where many problems of land use, management and health are so important. The empasis should be placed on applied ecology, or on basic research that will lead to direct application. Some of the applied and basic problems are related to : forest management and re-forestation or afforestation ; grassland and range management ; watershed conservation and erosion control ; wildlife preservation and management ; and more effective control of certain diseases of man and other animals. In addition some better management and use of dry areas, and in contrast, the flooded and wetland areas are needed. For each of these problems the time for contributions by ecology is short as population pressure and increased human needs accelerate.

Training of young scientist and the applications of the trained ecologists need direction toward management of natural resources of many kinds, especially the renewable resources, such as forests, grasslands, wildlife, and water. New and better ecological investigations and studies should be co-ordinated toward the most pressing of the particular problems of the kind referred to above.

Tropical problems in ecology are not essentially different from those of temperate regions and may be solved in the same manner, except that the needs for solution are more pressing in many tropical regions because of the excessive mis-management of the land and water areas over much of the tropics. Therefore, there is little time left for the luxury of the pure science or academic approach to ecology. The ecological research and applications should be productive toward human betterment soon, and toward some aspects of long-term conservation for future human use and enjoyment. Some productive ecological studies should include ; restoration to better use of semi-desert areas, and game and other wildlife ; watershed and flood control ; insect and worm control of those that carry or are diseases. Particular autecology studies of such plants as teak (*Tectona*) and sal (*Shorea*) and animals, such as the elephant, lion, antelopes, deer, water birds, jungle fowl, and many food fish could contribute to their better use, management and conservation. A great number of "tropical" diseases stem from mosquitoes and worms and ecological studies of these would aid in their control. Also ecological studies of man himself and his village and other communities is surely needed to select certain maladjustments the might be remedied in future societies, if not at present.

GERMINATION STUDIES IN *HYPTIS SUAVEOLENS* POIT. PART I—BREAKING OF DORMANCY AND EFFECT OF CERTAIN PHYSICAL TREATMENTS ON THE PERCENTAGE GERMINATION

By

M. C. SAXENA

Science College, Raipur, M. P.

INTRODUCTION

Hyptis suaveolens Poit., belonging to the family Labiatae, is an annual to perennial herb widely distributed in Chhattisgarh division and elsewhere in Madhya Pradesh. The species has been described as originally belonging to Tropical America by Taylor (1960), Mukherjee (1960) and Santapau (1960) (Private communications). The species has now got widespread in whole of India.

With the onset of monsoon, *Hyptis suaveolens* Poit. starts its growth from the seeds or previous year's root-stocks. Flowering sets in by the end of October. Fruits are ripe by November—December. Flowering and fruiting, however, have been noticed even upto March.

THE SEED

The seeds of *Hyptis suaveolens* Poit. are elliptical and flat with a median groove. The maximum and minimum lengths or seeds are 4 and 2 mm., respectively. The maximum and minimum weight of a seed is 0·00158 gm. and 0·00174 gm., respectively. The maximum and minimum volume of a seed is 0·0004 c.c. and 0·0001 c.c., respectively.

DORMANCY OF THE SEEDS

For the present study seeds were collected in the month of December—January, 1959–60. These fresh seeds did not germinate unless they were stored for some time.

Dormancy in seeds has been a major problem in seed physiology. Much work has been done in this connection by Barton and Crocker (1948); Crocker (1948) and Crocker and Barton (1953). Many factors have been assigned to overcome the dormancy and to find the possible causes for the same. The present paper describes the effects of certain physical treatments on the dormancy and percentage germination of seeds.

METHODS OF SETTING THE GERMINATION EXPERIMENTS

Germination was studied in pertidishes. 100 seeds were placed inbetween two soaked filter papers in a petridish. Petridishes were watered at intervals so that the filter papers do not dry. Number of seeds germinated each day was noted and these germinated seeds were removed. In order to avoid any fungal contamination the petridishes were washed with distilled water daily. Germination experiments were conducted in the month of March, 1960. Three replicates each treatment were set.

EFFECTS OF CERTAIN PHYSICAL TREATMENTS TO BREAK THE DORMANCY OF SEEDS

The following physical treatments were given to the seeds in order to determine the degree of success for each treatment :

(A) Mechanical scarification : By removel of testa.

Mechanical scarification of seeds with hard seed-coat has been found to give high percentage of germination (Crocker and Barton, 1953 and Shull, 1911 and 1914, etc.). Thus Watson (1948), Crocker and Barton (1953) have described the failure of many seeds to germinate because of hard and impermeable seed-coats.

Batches of 100 seeds of *Hyptis suaveolens* were first soaked in distilled water and then their seed-coat were carefully removed so as to avoid any injury to the embryo. The naked seeds were put for germination on agar-agar gel. All the seeds germinated demonstrating the impermeability of the seed-coat to water and oxygen.

(B) Radiant energy :

Dry or just soaked seeds were subjected to the following treatments :

1. Visible light of different durations.
2. X–rays.
3. Ultra–violet radiations.
4. Gamma–rays (γ–rays).
5. Electric shocks.
6. Infrared–rays.

Visible light :

Soaked seeds were exposed to visible light for the following durations :

(*a*) Continuous light.

(*b*) Continuos darkness.

(*c*) Alternate 12 hours light and 12 hours darkness.

(*d*) Alternate 18 hours light and 6 hours darkness.

(*e*) Alternate 6 hours light and 6 hours darkness.

For greater durations, artificial light was supplied by 60 watts electric lamp placed at a distance of $2\frac{1}{2}$ feet from the seeds and interposed by a water screen. During day the seeds received diffused light in the laboratory.

Certain seeds are known to require light for their germination (Crocker and Barton 1953, Crocker 1936, Thornton 1936 and Pandeya 1953). In the present studies, however, germination could only be initiated under alternate 6 hours light and 6 hours darkness. Here the percentage germination was only 21. Thus intermittent flashing of light is able to break the dormancy.

TABLE 1

Showing percentage germination under different durations of light period.

Durations of light supplied	No. of seeds germinated on each day (seed soaked on 10-3-60)								
	13-3-1960	14-3-1960	15-3-1960	16-3-1960	17-3-1960	18-3-1960	19-3-1960	20-3-1960	% germination
(*i*) Continuous light.	No germination.								
(*ii*) Continuous darkness.	do.								
(*iii*) Alternate 12 hours light and 12 hours darkness.	do.								
(*iv*) Alternate 18 hours light and 6 hours darkness.	do.								
(*v*) Alternate 6 hours light and 6 hours darkness.	3	2	4	2	3	Nil	7	Nil	21%
Control	–	–	1	–	1	1	–	–	3%

Effect of X-rays :

Dry and soaked seeds were exposed for different duration of X-rays. Sets of 100 seeds were taken in each case. Duration of exposure was increased from 10 seconds to 3 minutes with a gap of 10 to 15 seconds. After the treatment the seeds were placed for germination. The highest germination of 6% was observed under 3 minutes exposure to dry seeds and 30 seconds exposure to soaked seeds. It is thus been observed that X–rays accelerate germination and after breaks dormancy.

That seeds are sensitive to X-rays has been demonstrated repeatedly by Maxwell and Kampton (1939) and Kempton and Maxwell (1941). They have observed that X-rays promotes germination but high doses are harmful to it. However, in the present experiments, treatment upto 3 minutes has been found absolutely harmless.

When just soaked seeds were given the same treatment of varying durations percentage germination was high under all the durations of exposure.

Ultra-violet Radiations :

2, 3, 5, 7 and 10 minutes of exposure ultra-violet radiations were given to seeds, separately. Percentage germination was lower under this treatment than under the X-ray treatment experiments. Maximum percentage was 26, noted with 5 minutes exposure which fell to 4% with 10 minutes of exposure. Fuller (1930) has shown that plants of Tomato, treated with ultra-violet irradiations, increased in growth approximately over the control.

TABLE 2

Effect of X-rays on dormancy and % germination of seeds of *Hyptis suaneolens*. Poit.

Serial No.	Duration of X-ray exposure	Quality of seeds	Percentage germination
1	10 seconds	Dry	54%
2	20 seconds	,,	74%
3	30 seconds	,,	57%
4	40 seconds	,,	85%
5	1 minute.	,,	85%
6	1 Min. 15 Sec.	,,	50%
7	1 Min. 30 Sec.	,,	50%
8	1 Min. 45 Sec.	,,	65%
9	2 Min.	,,	68%
10	3 Min.	,,	86%
11	30 seconds	Soaked	86%
12	60 seconds	,,	78%
13	1 Min. 30 Sec.	,,	66%
14	2 Minutes	,,	66%
	Control	Soaked	3%

Gamma-rays (γ-rays) :

γ-rays treatment was given to seeds with a radium needle of 3 mg. for 30 seconds, 1 min. and 2 min. durations to dry seeds. The treatment was given on 20-6.-960 and seeds were set for germination on 27-6-1960. The percentage germination under different durations of treatment varied from 96% to 100% It may be added that during the period of this treatment control seeds showed 30% germination on the third day. Agulhon and Robert (1915) exposed pea seeds to three types of radiation activity. They found when emanation was permitted to diffuse from the radium directly into the space containing the seeds, there was an accelerating effect on early growth associated with some etiolation. In the present experiments no such etiolation was observed even with the further growth of seeds.

Electric shocks :

Seeds were given electric shock with 240 watts A. C. current by immersing the seeds in distilled water in a beaker acidified with few drops of hydrochloric acid. The current was passed through two copper electrodes immersed in the beaker. The duration of shock was 30 seconds, 1 minute, 1½ minutes, 2 min., 3 min., 4 min. and 5 minutes. After giving the shock seeds were thoroughly washed and put for germination. High germination was noted under 2 and 3 minutes of exposures, being 62 and 69% respectively. The percentage fell with higher durations.

The methods of subjecting the seeds to electric shocks was first of all described by Fraser and Pidgeon (1933). They have noted an accelerating effect on

germination by this treatment. In the persent studies an accelerating effect on germination has been noted when the shock is given for shorter durations.

Infra-red radiations :

Seeds were exposed for 3 to 8 minutes to infra-red radiations. Only 2 percent germination was noted when the seeds were exposed for 3 minutes. Under control at this time the germination was 6 percent. Thus a clear inhibiting effect of infra-red rays was observed.

The result correspond with the high temperature treatment, described in the following pages.

(C) Effect of temperature :

The following temperatures were given to dry seeds on 10th March, 1960 :

(*a*) At 0°C for 4 days.

(*b*) At 30°C for 4 days.

(*c*) Alternate 0°C and 30°C for the duration of six hours and eighteen hours, respectively, for four days.

(*d*) Alternate 0°C and 30°C for a duration of 12 hours each for four days.

(*e*) Alternate 0°C and 30°C for a duration of 18 hours and 6 hours for four days.

The seeds were then put for germination under laboratory conditions. No germination could be effected, under the first four temperature treatments. In the fifth case there was only 15% germination.

Thus germination could only be initiated under alternate cold and warm treatments.

DISCUSSION

The seeds of *Hyptis suaveolens* Poit. are elliptical and flat with a median groove. The maximum and minimum lengths of seeds are 4 to 2 mm., respectively The maximum and minimum weights of a seed are 0·004582 and 0·00174, respectively. The seeds which are ripe by November, were put for germination in the month of January, 1960. Seeds shown complete dormance at that time. When the same lot of seeds were germinated at the end of February, 1960, in laboratory conditions, upto 7% of germination was shown. Impermeability of seed-coat was found to be the main cause for this dormancy. This was confirmed by germinating the seeds after removing the seed-coat when 100% germination was obtained. Further experiments were conducted to study the effects of some physical treatments on the dormancy and percentage germination of the seeds.

Visible light of different duration does not appear to affect the seed germination. Only exposure to alternate 6 hours light and 6 hours darkness appears to effect the germination to some extent. Of other radiant energies X rays upto 3 minutes of exposure appear to favour germination appreciably. Ultra-violet radiations of long durations appear to be harmful. However, an exposure of short duration favours germination to a small extent. γ-rays also accelerate germination, although the results of γ-rays cannot be compared with other radiant energy treatments. This is, because it was given in the month of June, when in nature also seeds start sprouting, under control germination was

30% at this time. Under γ-rays germination rose to 100%. Electric shock with 3 minutes exposure appears to favour germination. Alternate cold and hot treatments of 18 hours and 6 hours respectively for four days initiated the germination but not to an appreciable mark.

The above observations may be interpreted as under :

(*i*) Increased respiration and enzyme activity as well as chemical changes in the embryo, endosperm and growth of embryo are some of the important physiological changes brought about by the temperature (Crocker and Barton, 1953).

(*ii*) Some physiological effects of X-rays on the seeds have been reported by Benedict and Kersten (1934) as being due to increase in diastatic activity and in sugar content.

Since the treatments given to the seeds of *Hyptis suaveolens* which promote germination are mostly connected with either increasing the rate of respiration or marking the seed-coat permeable to water, may be observed that the seed-coats of this species is probably impermeable to water and oxygen both. The permeability of seed-coat probably increases with resting of seeds. One of the secondary causes of the radiant energy treatment appears to be the increase in the permeability of seed-coat.

SUMMARY

Seeds of *Hyptis suaveolens* Poit. which are ripe by November were collected in the month of December–January (1959–60) and were immediatly put for germination without any success. A number of physical treatments were given to the seeds in order to break the dormancy and to study the effects of various treatments on percentage germination.

Impermeability of seed-coat was found to be the main cause of the dormancy. Of the other physical treatments, X-rays, ultra-violet rays of shorter durations, γ-rays, alternate 6 hours light and 6 hours darkness (visible light) and electric shocks have been observed to accelerate the precentage germination. Infra-red, other varying durations of visible light, high doses of ultra-violet rays and temperatures were found to retard the germination. All the seeds were viable, since they completely germinated with the removal of seed-coats.

ACKNOWLEDGEMENTS

The author wishes to express his heartfelt thanks to Dr. S. C. Pandeya, M.Sc., Ph.D., F.B.S. for his guidance and encouragement during the progress of the work and also for his critically reading the manuscript. He is thankful to Prof. P. C. Sethi, Head, Physics Department, College of Science, Raipur, Sri S. S. Iyer, Department of Physics, College of Science and Dr. U. Majpuriya, Radiologist, J. R. Hospital, Gwalior for their constant help. Grateful thanks are due to Dr. Karam Singh, Principal, College of Science, Raipur for facilities given.

REFERENCES

Afnasiev, M. 1944. A study of dormancy and germination of seeds of *Cercis Canadensis* *Jour. Agric. Res.* **69** : 405–402.

Agulhon, H. and Robert, T. 1915. The action of radium and radio-activity on germination in the higher plants. *Ann. Inst. Pasteur.* **29** : 261–273.

Barton, L. V. 1930. Hastening the germination of some coniferous seeds. *Contr. Boyce Thompson Inst.* **2** : 315–342.

Barton, L. V. and Crocker, W. 1948. *Twenty years of seed research at Boyce Thompson Institute for plant research, Inc.* 148 pp., Faber and Faber Ltd. London.

Benedict, H. M. and Kersten, H. 1934. Effect of soft X-rays on germination of wheat seeds. *Plant Physiol.* **9** : 173–178.

Crocker, W. 1916. Mechanics dormancy in seeds. *Annex. Jour. Bot.* **3** : 99– 20.

——— 1936. *Effects of visible spectrum upon the germination of seeds and fruits. In Biological effects of radiation.* **11** : 791–827. B. M. Duggar, Editor. McGraw Hill Book Co.

——— 1948. *Growth of plants.* Twenty years Research at Boyce Thompson Institute. 459 pp. Reinhold Publ. Corp., New York.

Crocker, W. and Barton, L. V. 1953. *Physiology of Seed.* pp. 276, Chronica Botanica Company, Waltham, Man., U.S.A.

Fraser, J. G. G. and Pidgeon, L. M. 1933. Electrolysis of Seed of Cereals *Sci. Agric.* **14** : 141–148.

Fraser, M. T. 1916. Parallel tests of seeds by Germination and by electrical response (Preliminary Experiments). *Ann. Bot.* **30** : 181–189.

Fuller, H. J., 1940. Stimulating effects of ultra-violet radiation upon higher plants. *Sci.*, **72** : 535–536.

Harrington, G. T. 1923. Use of alternating temperatures in germination of seeds. *Jour. Agric. Res.* **23** : 295–332.

Kempton, J. H. and Maxwell, L. R. 1941. Effect of temperature during irradiation on the X-ray sensivity of maize seed. *Jour. Agric. Research.* **62** : 603–618.

Maxwell, L. R. and Kempton, J. R. 1939. Delayed killing of maize seeds X-rayed at liquid-air temperature. *Jour. Washington Acad. Sci.* **29** : 368–374.

Shull, C. A. 1911. The oxygen minimum and germination of Xanthium seeds *Bot. Gaz.* **52** : 453–477.

——— 1914. The role of oxygen in germination. *Bot. Gaz.* **57** : 64–69.

Thornton, N. C. 1936. Carbon dioxide storage. I. Germination of lettuce seeds at high temperatures in both light and darkness *Contr. Boyce Thompson* Inst., **8** : 25–40.

Watson, D. P. 1948. Structure of the testa and its relation to germination in the papilionaceae tribes trifoliar and loteae. *Ann. Bot.* n s. **12** : 385–409.

ECOLOGICAL STUDIES ON THE HUMID TROPICS OF THE WESTERN GHATS, INDIA

By

B. S. AHUJA *and* K. P. SINGH

Central Botanical Laboratory, Allahabad

In India humid tropics is distributed along the high rainfall belt of Western Ghats, Assam and hill slopes of the Andaman Islands. The luxuriant vegetation of these regions and particularly that of the Western Ghats had been subjected to indiscriminate felling and burning, etc. Therefore, a detailed ecological appraisal of these forests is necessary for their best utilisation. A summary of the existing knowledge of tropical and subtropical forests of India has been presented by Puri (1960) recently.

Ecological problems in these areas were outlined by Puri (1956) at the UNESCO Symposium on Tropical vegetation. Following the recommendations of this symposium, Western Circle of Botanical Survey of India (Poona) started work on vegetation of Western Ghats under the supervision of Dr. G. S. Puri. Since then, the vegetation of Belgaum, North Kanara, Coorg, Shimoga, Chikamagalur and Kerala has been described, by Arora (1959, 1960), Ahuja (1959, 1960) and Ansari (1960). Puri (1959*a*, 1959*b*) and Puri *et al* (1960) have given an appraisal of progress on these studies. Some studies were also done on the evironmental factors. Geology and soils of these forests are of considerable importance in vegetation analysis and in this paper an attempt has been made at the suggestion of Dr. G. S. Puri to give a clear correlation as possible of forest types and the environmental features, notably soil.

General Physiographic Features :

Western Ghats extend southwards from Bombay along Malabar, parallel to the Arabian sea coast, down to Cape Comorin. The whole region is mountainous and form an undulating chain of hill projecting out from the main ghats. Palghat gap is the only major discontinuity of 20 miles in the ghat area. Average elevation of these mountains is 900 meters, although in the Nilgiris some of the peaks rise to 2400 meters or more.

Climate :

The climate of Western Ghats is monsoonic and most of the rain is received during June—September. Depending upon elevation, aspect and topography the rainfall varies between 100–500 cms., sometimes being more, *e.g.*, Pathmedi (Kerala) and Agumbe have 700 and 875 cms. of annual rainfall respectively. Throughout the year temperature fluctuates between 10–38°C. In wet-evergreen forest the temperature remains remarkably uniform and the mean annual temperature lies between 21–27°C. In moist tropical climates seasonal changes of temperature are insignificant compared with the seasonal variation in rainfall (Richard, 1952). The atmosphere is humid and morning humidity is seldom less than 80%.

Geology :

The chief geological formations of ghats are granite and gneiss (Wadia, 1957). Gneiss are often traversed by schists of auriferous Dharwar series, quartzite and

limestones of Kaladgi series and basalt belonging to the Deccan trap system (*e.g.* Belgaum, Kolhapur, Nilgiris, etc.). High and low level laterites occur in discontinuous patches, all oves the ghats, laid over formations of different ages (Wadia, 1957). Alluvial deposits occur along river banks and coasts.

Soils :

Raychaudhuri (1937, 1942) and others who have done considerable work on red and laterite soils, were primarily concerned with agricultural soils. Study of forest soils in relation to vegetation types has been taken up by Puri and his associates, Arora (1960), Ahuja (1961), Singh (1961). These workers have recognised red, black and leterite soil type in relation to plant communities in North Kanara, Coorg, Belgaum, Kolhapur and Chikamagalur forests. Physicochemical characteristics of these soils have been described by Seth and Yadav (1960), Yadav (1960), Misra and Puri (1960). Characteristic features of main soils types are briefly described below :

Red Soils : are derived from granites and gneisses and are porous and friable ranging in texture from sandy loam to clayey loam. Their surface is always covered with thick, moist layer of decomposing litter and their depth depends upon the topography of the locality. Calcium carbonate nodules are absent and the pH of these soils is near 5. Red soils are generally poor in calcium and nitrogen but richer in phosphorus and potassium than the Black soils. Red soils bear dense forests of wet evergreen and semi evergreen types.

Black Soils : are also derived from granites, gneiss or sometimes from basalt *in situ* and are alluvial in origin. They are dark in colour and slightly acidic in reaction, the pH being near about 6·5. They are richer in nutrients than the red soils. These soils bear moist deciduous vegetation of teak, bamboo, etc. or scrubby growth of *Gymnosporia, Bridelia, Butea*, etc.

Laterite Soils : are found *in situ* and are relatively poor in all plant nutrients. These soils are characterized by strongly acidic reaction and the presence of indurated honey combed mass which is developed from the separation of nodules of iron oxide and their gradual cementation. Clay complex is dominated by hydrous oxides of iron and aluminium, consequently their Silica/Sesquioxide ratio drops down to 1·33. Indian laterites have been investigated by Fox (1933, 1936), Krishnan (1935), Raychaudhuri (1937, 1941) and a summary has been given by Joffe (1949). These soils bear scrub vegetation in the Western Ghats comprising of *Randia, Gardenia, Zizyphus*, etc.

Vegetation :

The flora and vegetation of Western Ghats have been described by several workers (Beddome, 1876, Brandis, 1883, Fyson 1922, Fischer 1921, Aiyer 1932, Champion 1936, Bor 1938, Kadambe 1939, 41, 45, 50, 54, Nair 1953, 54, Banerji 1954, Puri 1956, 58, 60, Arora 59, 60, Ahuja 1959).

There has been a lot of discussion over the validity of application of phytosociological methodology, developed in temperate countries, to the study of Tropical vegetation. The very exhistence of 'association' in the wet evergreen forests has been denied by Van Steenis (1956) due to bewildering number and absence of gregarious habit in the constituent species. From Western Ghats, Aiyer (1932) has described a number of associations namely *Cullenia–Palaquium* ; *Palaquium–Megna* ; *Mesua–Callophyllum* ; *Vateria–Cullenie* ; *Vateria–Mesua*, etc. Champion (1936) stressed the need of more detailed study in making such an attempt. Puri and his associates have calculated the percentage occurrence of

various species in total number of quadrats and have recognized vegetation types from these data *e.g.*, in the vegetation of *Hopea–Myristica–Diospyros*, the dominant species has occurrence of 80% or more and the type is named as *Hopea–Myristica–Diospyros* community. Plant communities of North Kanara have been described by Arora (1960).

The following three principal vegetation types are met with in Western Ghats :

1. Tropical wet evergreen.
2. Tropical semi evergreen.
3. Tropical moist deciduous.

Tropical wet evergreen forests : are distributed at heights of 600–900 meters, in areas having annual rainfall usually above 200 cms. (Champion, 1936). Giant evergreen trees, usually 50 meters or more in height, having a clean bole upto 30 meters and possessing plank buttresses, smooth bark and thick and glossy leaves, dominate the forest. Abundance of woody climbers and epiphytes and seedlings of upper storey trees in the ground vegetation make the forest almost impenetrable. A thick layer of moist humus is always present.

These forests are generally 4–5 storeyed and may posses in the understoreys many deciduous trees. Common trees in the top storey are *Acrocarpus fraxinifolius, Artocarpus hirsuta, Balanocarpus utilis, Callophyllum ellatum, Cinnamomum zeylanicum, Diospyros microphylla, Dipterocarpus indicus, Donella roxburghii, Dysoxylum malabaricum, Elaeocarpus tuberculatus, Holigarna grahamii, Hopea parviflora, Hopea wightiana, Lepisanthes tetraphylla, Lophopetalum wightianum, Litsea stocksii, Knema attenuata, Machilus macrantha, Mesua ferrea, Myristica beddomei, Pala quium ellipticum, Poeciloneuron indicum, Polyalthea fragrans, Pithecolobium bigemium.*

The second storey (25–30 meters ht.) has a good number of top storey species like *Cinnamomum zeylanicum, Diospyros microphylla, Myristica attenuata, Polyalthea fragrans* with others like *Actinodaphne hookerii, Alstonia scholaris, Aporosa lindleyana, Caryota urens, Diospyros* sp., *Elaeocarpus serratus, Eugenia gardeneri, Flacourtia montana, Garcinia* sp., *Holigarna gahramii, Hydnocarpus wightiana, Lonociera malabarica, Olea dioica, Strychnos nux-vomica, Symplocos* sp., *Terminalia* sp.

The third storey generally does not exceed 10 meters. The species present are *Callicarpa lanata, Canthium dicoccum, Eugenia* sp., *Flacourtia montana, Ixora nigricans, Leea indica, Maesa indica, Mappia foetia, Olea dioica, Randia brandisii, Symplocos* sp.

The following shrubs are abundant : *Breynia patens, Chasalia curviflora, Clerodendron infortunatum, Ixora* sp., *Murraya koenigii, Pschotria* sp., *Leea indica.*

Bamboos, canes and palms are represented by *Calamus pseudotennuis, Calamus* sp., *Arenga wightii, Ochlandra* sp., *Pinanga dicksonii.*

Climbers are : *Allophyllus serratus, Asparagus racemosus, Calycopteris floribunda, Clematis* sp., *Cissus* sp., *Cyclea peltata, Entada phaseoclodies, Gnetum ula, Hemidesmus indicus, Heptapleurum venolosum, Jasminum rottlerianum, Naravalia zeylanica, Piper nigrum, Pothos scandens, Toddalia aculeata.*

Herbs are few and generally belong to *Zingiberaceae* and allied families, with ferns like *Pteris quadriaurita, Pteris aquillina, Arigiopteris erecta, Gymnopteris* sp., *Pteris pellicida, Stenochlena chinensis.* Amongst the epiphytes species like *Pholidota imbricata, Oberonia* sp., *Aerides* sp., *Bulbophyllum* sp., *Dendrobium* sp., are common.

Tropical semi evergreen forsts : In Western ghats this type occurs as a narrow strip between wet evergreen and moist deciduous forests. It is rather ill defined due to the presence of species characteristics of the two adjoining types (Champion 1936). This type occurs in areas having 150–200 cms. annual rainfall and a yearly dry season of 3–4 months. Trees attain the height of 40 meters and are occasionally buttressed. Climbers and epiphytes are abundant.

The top storey is formed by number of evergreen and deciduous species like : *Alseodaphne semocarpifolia, Aporosa lindleyana, Actinodaphne* sp., *Artocarpus hiruta, Celtis cinnamomea, Cinnamomum zeylanicum, Eugenia* sp., *Flacourtia montana, Heynea trijuga, Macaranga peltata, Tabernaemontana heyneana, Terminalia paniculata, Terminalia tomentosa.*

The second storey has *Grewia microcos, Grewia tiliaefolia, Mappia foetida, Tabernaemontana heyneana, Terminalia tomentosa.*

Important shrubs are *Clerodendron infortunatum, Hollarhena antidysentrica, Leea indica, Psychotria* sp. *Zizyphus* sp.

Climbers are represented by *Cissus* sp., *Cyclea* sp., *Derris* sp., *Dioscorea* sp., *Diplocilisia glaucescens* are seen. *Gnetum ula* is occasionally noted and *Calycopteris florbunda* is observed along edges and forest openings.

In the undergrowth herbs like *Costus speciosus, Curculigo* sp., *Curcuma* sp., *Cyanotis* sp., *Elephantopus scaber,* and ferns like *Adiantum* sp., *Pteris* sp. are common. Seedlings of evergreen species *e.g. Cinnamomum, Holigarna, Olea, Litsea* and others are often observed.

Tropical Moist deciduous forest : These forests are developed on riverain alluvium, having annual rainfall between 100–150 cms. and annual dry season of 4–6 months. These forests often attain a height of 30 meters or so and the dominant trees are mostly leafless during the dry season. Evergreen species are absent or else may be met with in the understorey. Teak and/or Bamboo forests are priminants in this type.

The top storey of these forests comprises of *Adina cordifolia, Albizzia* sp., *Bauhinia* sp., *Dalbergia latifolia, Dillenia pentagyna, Diospyros montana, Emblica officinalis, Ficus* sp., *Gmelina arborea, Kydia calyceria, Lagerstoemia lanceolata, Lannea grandi Engenia dalbergeoides, Pterocarous marsupium, Saccopetalum tomentosum, Sterculia* sp., *Teetona grandis, Terminalia* sp., *Xylia xylocarpa, Zanthoxylum rhetsa.*

Small trees of *Callicarpa tomentosa, Careya arborea, Bauhinia* sp., *Hollarhena antidysentrica, Leea indica, Mappia foetida, Meyna laxiflora, Randia brandisii.*

Shrub layer consists of *Carissa congesta, Carvia callosa, Colebrookia opposiraefolia, Lantana, Leea indica, Murraya koenigii, Solanum* sp., *Zizyphus oenoplea, Z. rugosa, Z. xylopyra.*

Amongst the climbers the following are well represented : *Acacia concenna, Asparagus racemosus, Calycoptereis floribunda, Cissus* sp., *Cryptolepis buchanani, Diplochisia glauce-scens, Smilax, Entada* with *Wagatea* occasionally occurring at places.

The undergrowth consists of herbs like *Crotalaria* sp., *Desmodium triquetrum, Mimosa pudica, Flemengia* sp., *Sida* sp., *Triumfetta* sp., *Urena lobata,* with grasses like *Apluda aristata, Eragrostis* sp., *Oplismenus* sp., *Themeda* sp.

Most common bamboos are *Bambusa arundinaceae, Dendrocalamus strictus, Ochlandra talboti, Oxytenthera monstegina.*

Scrub forests : Scrub forests are mostly due to biotic or bioedaphic factors. These forests may be distributed over Black soils or Lateritic soils.

Characteristic species of Black soil scrubs are *Gymnosporia montana, Ixora parviflora, Carissa congesta, Bridelia stipularis, Zizyphus* sp., etc. In water logged areas *Butea* scrub and been noted. Occasionally, *Diospyros melanoxylon* and *Lagerstroemia parviflora* may be present.

On the other hand lateritic scrubs are comprised of *Glochidion, Gardenia, Flacourtia indica, F. montana, Terminalia chebula, Canthium umbellatum, Careya arbora, Ixora coccinea*, etc. Important climbers are *Celastrus paniculata, Jasminum malabarica*, etc. Sometimes evergreen species like *Vitex altissmia, Olea dioica* may be noted.

TABLE I

North Kanara (data after Singh, 1961)

Soil Sample No.	Vegetation	Exchangeable bases, m.e. % Calcium	Magnesium	Potassium
37	Wet Evergreen : *Dipterocarpus turbinatus, Holigarna, Caryota, Litsea, Olea dioica, Ancistrocladus, Calamus, Piper, Pothos, Psychotria, Leea.*	15·18	6·31	5·43
10	Semi evergreen : *Xylia xylocarpa, Tabernaemontana heyneana, Cinnamomum zeylanicum, Allophylus cobbe, Acacia concina, Atalantia* sp., *Glycosmis pentaphylla.*	20·57	7·18	1·507
5	Moist deciduous : Bamboo, *Tectona grandis, Terminalia tomentosa, Albizzia calycopteris, Zizyphus rugosa, Dalbergia paniculata.*	25·64	6·79	1·15
49	Lateritic scrub : *Glochidion, Butea, Careya, Celastrus paniculata, Bridelia, Canthium, Olea dioica, Syzigium cuminii.*	7·69	2·12	1·91

Soil-vegetation relationship :

In tropics the correlation between the soil and the natural vegetation is always close and the plant communites reflect differences in soil conditions (Richards, 1952). In Western ghats vegetation types are supported over distinct soil types, as described above. In these distincts of Western ghats, namely North Kanara, Shimoga and Chikamagalur, chemical analysis of soil done by us has indicated interesting relationship between vegetation types and the soill bases like Calcium and Potassium. The data given in the table I and II may serve to illustrate the relationship.

It is evident that the amount of exchangeable Calcium, which is lowest in red soils bearing wet evergreen forest, increases in red soils supporting semi-evergreen forest and becomes highest in the black soils bearing moist deciduous forest. While exchageable Magnesium of soils seems to be indifferent to vegetation types, opposite relationship has been indicated in the case of exchangeable Potassium *i.e.*, the amount is highest in wet evergreen forest soils and decreases through semi evergreen to moist deciduous forest soils. Laterite soils although poor in Calcium and Magnesium are relatively richer in Potassium. Tables I and II show the relationship of vegetation to exchangeable Ca, Mg and K.

TABLE II

Shimoga and Chikamagalur (data after Ahuja, 1961)

Soil Sample No.	Vegetation	Exchangeable bases, m.e. % Calcium	Magnesium	Potassium
1	Wet evergreen : *Poeciloneron indicum, Mesua ferrea. Elaeocarous tuberculatus, Olea dioica, Cinnamomum zeylanicum, Psychoria truncata, Pinunga* sp.	1 ·3	10·5	5·1
5	Semi evergreen : *Olea dioica, Tabernaemontana heyneana, Syyigium cuminii, Xylia xylocarpa, Ixora* sp. *Randia* sp.	18·4	5·6	4·8
7	Moist deciduous : *Tectona grandis, Emblica officinalis, Dendrocalamus strictusr, Terminalia paniculata.*	20·2	9·4	1·06
12	Lateritic scrub : *Ixora bracheata, Syzygium caryophyllacea, Randia* sp., *Canthium umbellatum, Glochidion, Gardenia.*	6·6	2·2	1·9

ACKNOWLEDGEMENT

Acknowledgement is made to Dr. G. S. Puri for valuable suggestions during the course of this study.

REFERENCES

Ahuja, B. S. 1959. Flora of Deccan Trap Country. II. Plants from Belgaum and Kolhapur. *Proc. Ind. Sci. Cong,* 303.

——— 1960. Botanical Exploration of Shimoga and Chikamagalur. *Proc. Ind. Sci. Cong,* 420

——— 1961. Studies on the Soils of the Humid Tropics, Western Ghats, *Proc. Ind. Sci. Cong. Abst.* 369.

Aiyer, T. V. V. 1932. The Sholas of the Palghat division. A study of ecology and silviculture of the tropical rain forests of Western ghats. *Ind. For.* **58** : 414–432, 473–486.

Ansari., 1960. Studies on the vegetation of Kerala (unpublished).

Arora, R. K. 1959. Ecological studies on deciduous forests of Noth Kanara. *Proc. Ind. Sci. Cong. Abst.*

——— 1960. Flora of North Kanara. *Ind. For.* **86** : 603–616.

Banerji, J. 1954. Tropical rain forest. *Proc. IV World For. Congress.* Dehra Dun. (1) : 82–89.

Beddome, R. H. 1876. The forest and flora of the Nilgiris. *Ind. For.* **2** : 17–28.

Bor, N. L. 1938. The vegetation of the Nilgiris. *Ind. Forester* **64** : 600–609.

Brandis, D. 1883. On distribution of forests in India. *Ind For.* **9** : 174–83, 221–233.

Champion, H. G. 1936. A preliminary survey of forest types of India and Burma. *Ind. For. Ree.* (N. S.), 1.

Fischer, C. E. C. 1921. A survey of flora of the Anamalai Hills in the Coimbatore district, Madras Presidency. *Rec. Bot. Surv. Ind.* **9** : 1–218.

Fox, C. S. 1933. Laterite and laterite soils. *Ind. For.* **39** : 632.

Fyson, P. E. 1922. The ecology of the Nilgiri hill tops. *Proc. 9th Ind. Sci. Cong . Abst.*, 118.

Joffe, J. S. 1949. Pedolosy, Podolosy publication, New Jersy (second edition).

Kadambe, K. 1939. The montane evergreen forests, Bisle region. *Ind. For.* **65** : 189–201.

——— 1941. The evergreen rain forests–Agumbe- Kilandur zone. *Ind. For.* **67** : 184–204.

——— 1945. A working plan for the ghat forests 1941–46. Bangalore, i–384.

——— 1950. Evergreen montane forests of the Western ghats of Hassan district, Mysore State. *Ind. For.* **76** : 18–30, 69–82, 121–132.

——— 1954. Methods of increasing growth and obtaining Regeneration of Tropical Forests. *Proc. IV World Forestry Cong*, Dehra Dun.

Krishnan, M. S. 1935. Laterization of Khendalite. *Rec. Geol Surv. Ind.* **683** : 392–399.

Misra, R. and Puri, G. S. 1954. Indian Manual of Plant Ecology, Dehra Dun.

Nair, K. N. R. 1953. Problem of Tropical silviculture and management of rain forests of S. India. *Ind. For.* **79** : 376–382.

——— 1954. Tropical Rain forest. *Proc. IV World For. Cong.* 209–214.

Puri, G. S. 1956. Problems in the ecology of the Humid Tropics. *UNESCO Sym. Kandy* Ceylon.

——— 1958. Studies on the vegetatian of Humid tropics of India. *UNESCO Sym. Bogor*, Indonesia.

Puri, G. S. 1959 *a*. Vegetation of India, its past, present and future. *IX Int. Bot. Cong. Montreal*, Canada.

——— 1959 *b*. The concept of climax in forest Botany of India. *Ibid.*

——— 1960. Indian Forest Ecology, *Delhi.*

——— *et al*. 1960. Studies on the vegetation of Humid Tropics of India. *Trop. Moist Eyer. Forests Symp.* F. R. I., Dehra Dun.

Raychaudhuri, S. P. 1937. On the nature of laterite and lateritic soil. *Sci. and Culture*, **3** : 69–74.

——— 1941. Studies on Indian red solis. III. General morphological characteristics of some profiles. *Ind. Jour. Agri. Sci.* **11** : 220– 36.

Richards, P. W. 1952. The tropical rain forest (an ecological study). *Camb. Univ. Press.*

Singh, K. P. 1961. Studies on the soils of the humid tropics of India. *Proc. Ind. Sci. Cong. Abst.* 369.

Seth and Yadav, 1960. Soils of the Tropical Moist Evergreen forests of India. *Ind. For.* **86** : 401–413.

Van Steenis, 1956. Basic Principles of rain forest sociology. *UNESCO Sym. Kandly*, Ceylon, 159–164.

Wadia, D. N. 1957. Geology of India, *London.*

Yadav, 1960. Soils of the dry zone of India. I. General. *Ind. For.* **86**, 274–295.

THE SUCCESSION ON FOREST COMMUNITIES IN THE FORESTS OF THE DEHRA DUN AND SAHARANPUR FOREST DIVISIONS

By

G. S. PURI

Central Botanical Laboratory, Allahabad

INTRODUCTION

The Siwaliks between the Ganges and the Jamuna bear a mixed moist deciduous forest of species that are nearly tropical or sub-tropical in distribution. These hills have on an average a height of over 1400 feet (424 meters) above sea level ; the highest ridge being about 3,000 feet (909 meters) in elevation. The forests on the northern slope which appear to be somewhat better developed, on the whole, constitute the Dehra Dun forest division ; and those on the southern slope of the Siwaliks, and a part of the plains at the foot of these hills belong to the Saharanpur forest division. They were brought under scientific management in the latter part of the 18th century and since then are being managed under working plans, which are revised periodically.

By far the commonest tree species in these forests is sal ; the majority of the forests, however, lie in Dehra Dun division. The small pockets of sal forests in the Saharanpur division have been shrinking since the 18th century, and most of these have now little or no regeneration of sal. The regeneration of other deciduous species is also inadequate and large areas of forests have become converted into treeless grassy meadows, or savannas, with a scattered tree growth. Except for very small areas where ground flora vegetation consists of dicotyledonous species and ferns, these forests have a grassy undergrowth and hence support a large cattle wealth.

Champion (1933, p. 32) classified these forests in "A" dry Siwalik sal which according to him is a transition from a moist hill sal to a mixed dry deciduous forest.

The forests on the northern slope of Siwaliks are moist deciduous in nature, with a much higher percentage of sal. Trees have a better growth and are a source of considerable amount of revenue. Some of the sal forests on this slope also suffer from a lack of regeneration at places and have shown a tendency to develop to a mixed deciduous type, or to a treeless grassy meadow of moist or dry type.

Champion (1933) classified most of these forests into "B_3" moist high level alluvium sal which represents a stable sub-climax stage. However, he considered that the climax forest for this region is a mixed sal forest with a higher percentage of species other than sal and a thick undergrowth with woody climbers.

In addition to these two main types there is an endless variety of forest communities, the exact relationship of which is not clearly known as yet.

Physical environment of the Siwalik forests :

(*i*) *Geology and soils* :

In an earlier study (Puri, 1950) of the forests of the Dehra Dun valley a short description of geological, topographical and physiographic features of the Siwaliks was given. It might be added that the Siwaliks constitute a distinct plant

habitat which is intermediate in characters between the Himalayan mountains on the north and the plains in the south.

In the revised Working Plan for the Saharanpur forest division, Srivastava (1951) has given detailed descriptions for the Southern slopes and in his plan for the Dehra Dun division Sahay, (1951) has described the northern slopes of the Siwaliks. Briefly stated, the strata of the Siwaliks consist of conglomerate, clays, and sand rock, which are interbedded and alternate irregularly. These strata show a general dip towards north and east, but on account of the intense folding, thrust-faulting, etc. to which these hills were subjected by the late Himalayan orogenies after their deposition, the dip of the strata locally changes abruptly from north-east to south and south-west. Thus, although, the southern slopes of the Siwaliks represent a general escarpment, local places with a southern dip slope also occur. Similarly, on the northern slope there are local escarpments in a general dip slope. Due to the disturbances to which these hills have been subjected and the sub-aerial denudation different rock strata outcrop on the surface in adjoining localities along the same horizontal plane. Thus, at the same altitude all the three types of rock may be found, and since the forest vegetation is determined largely by geological nature of the substratum in this region, different types of forests that may usually conform to a particular altitudinal distributional pattern occur in an heterogenous manner at one altitude. In a compartment of the size of one hundred acres there may often occur more than one type of forests and related to physiography, geology and soils.

The soils in the region range from the residual conglomerate, clay, sand rock, to newly deposited shingle, gravel, silt, sand or clay and to exposed surfaces *in situ* that may resemble the newly deposited soils in appearance. All these have different morphological and physiological features. The relationship of the one type of the soil with the other and the properties of the same type at different places are dependent on their position with respect to the dip and the scarp. Further, the entire Siwalik region being intermediate between the mountains and the plains in soil development the features of these soils are midway between the two. The soils on the scarp are physiologically dry, shallow and generally less fertile, resembling new deposits or eroded and newly exposed surfaces. Soils on the dip slope are generally more stabilized, moist, and deep. These tend to develop a zonation and are sometimes recognisable as brown earths. On account of the friable nature of these strata the soil in the area are greatly mixed. Erosion and re-deposition further destroy whatever differences these soils may have in their chemical properties.

(*ii*) *Climate* :

Rainfall, being the chief source of water supply, has been considered first and from the data available the rainfall pattern for some of the places in the area are given in figure 1.

In the area there seem to be four distinct plant growth seasons. The winter is characterised by low temperatures with a little rainfall, merging with a short autumn that is usually dry. There are dry hot and wet hot periods. Although, the annual rainfall in the area is heavy, the net effect of climate on soil and vegetation development is the production of a zonal soils, bearing a mixed deciduous type of vegetation. However, local pockets with favourable moisture content and nutrition level, bearing slighty different types of vegetation, occur in the area.

Summing up, the climate in the Siwaliks on the whole, is dry with a distinct alternations of wet and dry periods. It produces zonal soils in which upper layers

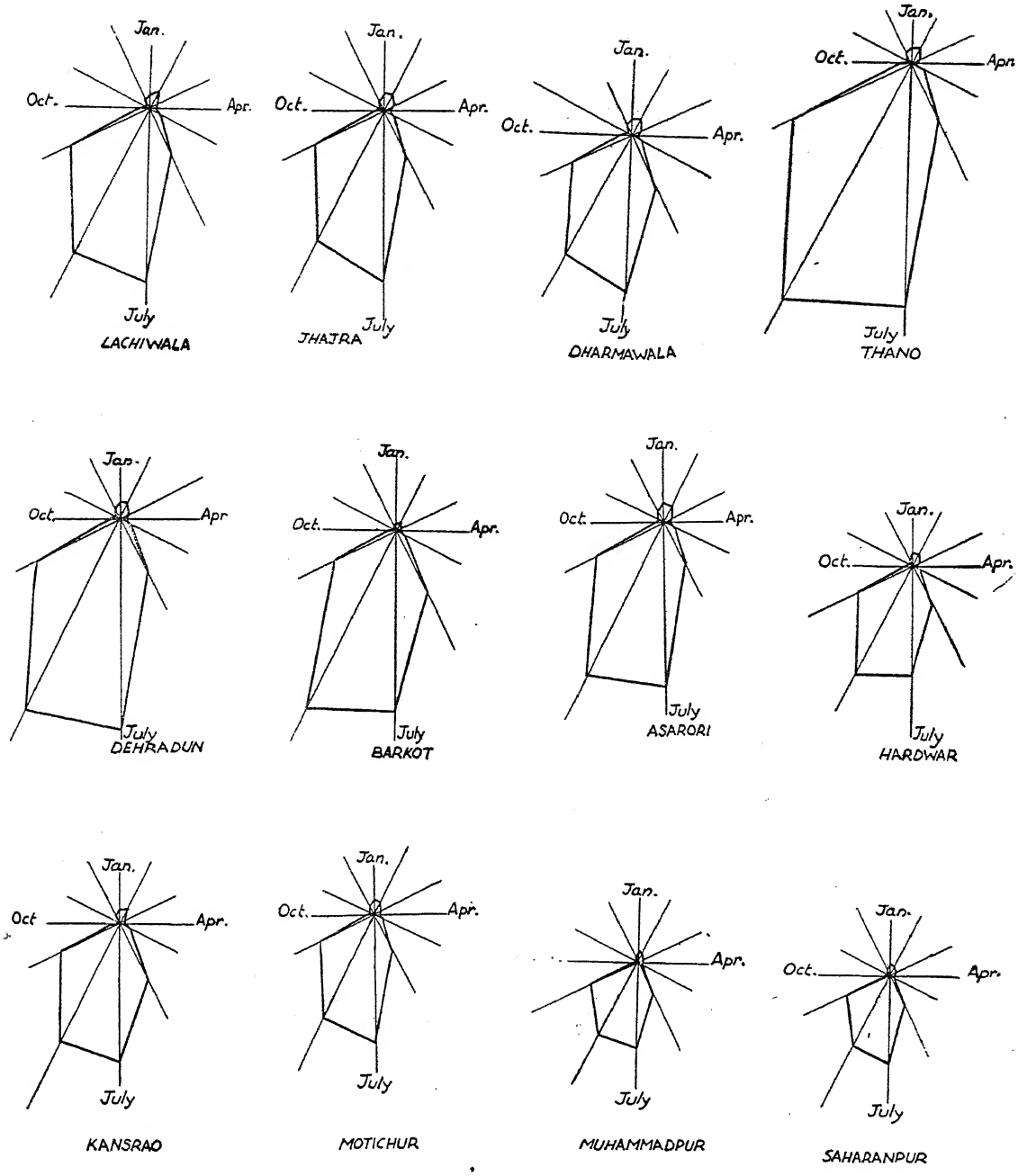


Fig. 1. Rainfall patterns of localities in the Dehra Dun and Saharanpur forest divisions. The patterns are prepared from monthly rainfall data.

of the soil get enriched in bases by evaporation if there is no erosion. This type of soil development is more pronounced in conglomerates and sandrocks which are porous. In clays the development of the soils is, on the whole, slow, and the effects of leaching and evaporation are seen distinctively in soil profiles.

The physical environment of the area, is on the whole, conductive for the development of forest communities, which are of a moist deciduous type.

Forest biota :

On account of the mild climatic conditions and fertile soils the area is eminently suitable for the growth of animal population. There are a large number of wild herbivorous animals including elephants, which cause no small damage to standing crops of trees and tree seedlings. By far the important set of animals that causes a considerable damage to forest crops and slowly brings about changes in soil and crop conditions are domesticated cows, buffaloes, goats, sheep and camels. The effect of the biota on the growth and development of forest is of the following types :

1. Selective grazing may wipe out some types of plants that are palatable, and may provide protection to and help in the growth of unpalatable species. The presence of clumps of *Adhatoda vasica, Clerodendron infortunatum, Carissa, Zizyphus* spp. etc. in some of the forest communities may be partly due to biotic factor.
2. The animals provide a raw manure in the forest, which promotes the growth of a number of species like *Cannabis sativa, Xanthium strumarium Cassia tora,* etc.
3. Cattle very often disperse seeds of plants, bringing in those that are foreign to a forest community.
4. Trampling of soil by cattle brings about important changes in the soil. The upper layers of the soil get compacted and such soils dry earlier in summer and tend to become somewhat water-logged during rains. On the whole, heavy grazing makes the soil drier, compacted and somewhat less fertile and consequently favours the growth of vegetation of a drier type.

Another biotic feature is fire. In addition to bring about chemical changes in the upper layer of the soil, fire makes the soil dry by destroying organic colloids.

General physiognomy of vegetation :

Under the physical and biotic environments described above the stable vegetation in the area would probably be an open mixed deciduous forest, with a fairly prominent grassy growth. There are, however, a number of successional stages, observed as more or less stable sub-climax communities, which are composed of either purely evergreen species or of deciduous types. In still another case savanna or grassy meadows without any tree growth may occur due to biotic or edaphic conditions.

The forests are generally uneven-aged and irregular with a broken canopy due to the presence of deciduous species, scattered along with evergreens. In some of the sal forests the conversion of the forest crop to uniform has been attempted and large stretches of regular forests are now found along with irregular natural crops. Alter conversion these forests become pure and are left with only one

or two tree species of which one is always sal. Thus, the effort has been in the past to convert these forests into pure sal communities, often with disastrous results on conglomerates and other porous soils.

Some of the commonest species in the upper storey in the forests are *Shorea robusta*, *Terminala* spp., *Syzygium cumini*, *Albizzia*, *Anogeissus*, *Lagerstroemia*, etc. There are a large number of second storey trees of which *Kydia calycina*, *Grewia* spp., *Ficus* spp., *Buchanania latifolia*, *Ougeinia dalbergioides*, etc. are common. There are numerous under-storey plants like *Casearia tomentosa*, *Mallotus*, *Holarrhena*, *Carissa*, *Ehretia laevis*, *Litsaea* spp., *Nyctanthes*. Where these species have been cut for silvicultural reasons they have developed bushy growth, forming a thick impenetrable cover. There are a number of small shrubs of which *Clerodendron infortunatum*, *Colebrookea oppositifolia*, *Adhatoda vasica*, *Flemingia* spp., *Pogostemon*, *Murraya koenigii*, *Indigofera*, *Woodfordia*, deserve a special mention. Of the commonest grasses *Sechharum* spp., *Vetiveria zizanoides*, *Phragmitis karka*, *Oplismenus compositus*, *Imperata cylinderica*, *Cynodon dactylon*, *Arundo donax*, etc., may be mentioned. Two species of *Adiantum* occur frequently in these forests. There are a number of climbers in the area of which *Bauhinia vahlii*, *Milletia auriculata*, *Ichnocarpus fruticens* are the commonest. On riverain deposits *Bombax malabaricum*, *Adina*, *Albizzia*, *Acacia*, *Dalbergia*, *Holoptelia*, *Trewia*, *Putranjiva*, *Aegle*, etc. are important species. *Tamarix dioica* also occurs in big clumps on river sands. *Zizyphus* spp., *Randia*, *Cassia fistula*, *Lagerstroemia parviflora*, etc. occur in savanna, which is a degraded sal forest. *Butea monosperma* is found in some riverain areas, either locally pure, or in mixture with other species. Bamboos, chiefly *Dendrocalamus strictus*, are also found in mixed deciduous forests at places.

In addition to the natural forests communities described above *Taungya* plantations of *Acacia catechu*, *Dalbergia sissoo*, sal, Bamboo, etc. have been raised in the area. These single storeyed forests have usually a grassy undergrowth in which *Ageratum conyzoides*, *Cassia tora*, *Xanthium*, etc. are found almost invariably.

While most of the forest communities in the area are composed of broad leaved species *Pinus roxburghii* occurs in fair abundance in some localities towards the crest of the Siwaliks on conglomenate. Here, it tends to form an upper storey with sal and some of its associates.

All the forest communities in the area are hardly natural in composition or structure. These have been tended into their present physiognomy, by systematic exploitation, selective cutting, silvicultural treatments, etc.

Forest types on clays and Dun gravels :

Almost all the sal forests of the area occur on the Siwalik clays which are mostly shallow and not extensive. These form residual soils and are non-calcareous and ferruginous. Being relatively impervious, clays hold sufficient amount of water for the growth of plants. These have a fair admixture of sand and where they are shallow, there is a layer of conglomerate, either below or above it. These are at most places well drained. The clays bear degraded and highly disturbed sal forests, and savanna, usar or swampy grasslands, with little or no tree growth. All these are biotic controlled communities.

The following examples have been studied on clays :

Shallow clayey soils on the northern face of the Siwaliks in the Timli Range bear a more or less pure community of *Shorea robusta*. In Dararit Compt. No. 4 the crop is young, mostly coppice and uniform. It is dense and there are hardly any ground flora species. Tree seedlings are also fewer.

The sal crop consitts of young coppiced poles and is very dense with as many as 20–30 poles within a radius of 15 ft. of the soil profile. In the under storey very small shrubs of *Mallotus, Ehretia, Litsaea, Hollarhena* and *Clerodendron* are present. The ground flora is very sparse with a few scattered coarse grasses present here and there. There are no seedlings of sal on account of the crop being young. Seedlings of *Milletia, Mallotus* etc. are present. The soil has a thick layer of undecomposed leaf litter and is somewhat shallow and stones are usually present at various depths. There is a good admixture of sand and clay. Roots are present upto a depth of 24 to 26 inches.

In Dharmawal block sal high forest in P. B. Inter stage was studied. Big trees of sal scattered with 4 to 6 trees in an area of 15 ft. radius were found. The undergrowth consisting of *Mallotus* (coppiced), *Litsaea, Milletia* (cut back) and *Clerodendron* formed a dense 6 to 8 ft high "blanket". The ground flora vegetation consists chiefly of *Adiantum, Pogostemon* and little grasses. In this area there were only a few sal seedlings.

Soil is clayey with fair admixture of sand and is of a slightly brownish colour. It is deep with little or no stones and roots are present upto a depth of 24 to 36 inches. The number of roots usually decreased below 12 inches.

Deep clayey soil bear a sal–*Syzygium* community in Lal Dhang block comptt. 10-A at Asarori. The vegetation consist of large trees of sal with some poles. Tress of *Syzygium* form a part of the upper canopy. In the second storey are also found *Syzygium* and sal along with *Mallotus, Litsaea,* etc. The undergrowth is fairly dense and the ground vegetation consists of *Adiantum* and grasses. Seedlings of sal are abundant and forests were mixed and irregular.

The soils are deep with none or a few stones upto the depth of 48 inches.

In Koelpura block at Kansrao sal forests on clay present an entirely different picture. Due to over-exploitation the forests are very open and have a thick grassy undergrowth below the upper storey. The soil here, though clayey, is dry. It is not radically different from the clays at other places in chemical characteristics but due to biotic factor the soil has become dry and compact resulting in the development of grasses at the expense of sal and other seedlings. The seedlings of sal where present do not show healthy growth.

In the same comptt. at Kansrao where biotic disturbance has not been so intense the vegetation consists of sal trees with *Syzygium* and *Terminalia* in the upper storey. In the second storey *Mallotus* is common. *Clerodendron* is almost the only species in the ground layer with a few seedlings of sal, *Mallotus* and *Syzygium.*

Sal forms a community with *Terminalia tomentosa* on clayey soils, which are somewhat dry. This dryness may be partly due to the open nature of these forests or to the composition of the soil. *Terminalias* occur in the upper storey with sal. In lower storey *Ougeinia* or sometimes *Buchanania* and *Anogeissus* are also present. Such forests are usually open and there are little or no ground species. The seedlings of sal are usually not present.

In sal forests, pure patches of other species also occur on clayey soils with slightly different moisture content. Thus, a patch of *Ougeinia dalbergioides* is found in Barkot Range in Sainkot Block. Trees of *Ougeinia* are tall with clear bole of 40–50 feet. The middle storey is formed of *Mallotus, Ehretia laevis* and sometimes *Cordia dichotoma.* Seedlings of sal, *Ougeinia* and *Mallotus* are present.

The soil is deep and clayey but very much compacted. The upper few inches of the soil are black in colour with a high percentage of organic matter. It is highest so far seen in forests of this area.

On dip slope clayey soils possess different moisture equilibrium. At higher elevations these are well drained and somewhat dry. But at lower elevations in the Dun Valley they have a high water table and at some places become badly drained, especially from where tree vegetation has been removed. These clayey patches develop a "sea" of grass and tree vegetation suffers greatly. The only species that has been seen growing in such areas is *Lagerstroemia parviflora.* In Bibiwala Block of the Barkot Range the forest has degraded into a savanna-like habitat. Here *Lagerstroemia parviflora* is almost the only tree species. Sometimes a very much scattered middle storey of *Mallotus, Ehretia, Holarrhena, Zizyphus* and *Randia,* which are remnants of the past vegetation in the area may be seen. The soil is compacted and inspite of the very open nature of the forest and low organic matter it is fairly moist. It is brown in colour and breaks into large lumps.

At some places on the dip slope in clayey soils where the water table is very high near stream beds the habitat develops characteristic of Tarai and where tree vegetation is once removed the area becomes swampy. Near the Forest Rest House at Kansrao a few soil profiles were examined in the swampy area, with cane. The tree vegetation consists of *Trewia nudiflora, Syzygium cumini.* Here organic matter in the soil is very high and water table was between 12"–18" of the surface.

On scarp slope the clay is generally drier and removal of tree vegetation results in further dryness. In Tira Block of the Dholkhand Range areas grassy savanna develop that are different in aspect from the moist savanna.

These soils, on account of their dryness and open nature of vegetation, which is mostly deciduous, have low relative humidity and high exchangeable Ca in the whole profile.

Forest types on conglomerate :

The conglomerate rock is generally conspicuous on the southern scarp slope of the Siwaliks, especially in steep valley sides and bears a mixed community of deciduous species, chiefly *Anogeissus latifolia, Bauhinia* spp., *Terminalia belerica,* with a second storey of *Ougeinia dalbergioides, Buchanania latifolia* etc. The common shrubs are *Nyctanthes, Carissa, Woodfordia, Colebrookea,* etc. *Bauhinia vahlii* is usually the commonest climber. The most common grass is *Eulaliopsis* which forms thick tussocks covering conglomerates. Chir pine is usually present along with other species. Since the soil is very stoney and shallow there is none or little ground flora vegetation, excepting grasses. On the martix of the conglomerate rock a numder of small liverworts, ferns and *Selaginella* are found. Among these some dicotyledonous herbs may spring up during the monsoons.

The martix of conglomerate is formed of a coarse sand, which contains variable quantities of $CaCO_3$ as the chief binding material.

Eroded surface are colonised by seedlings of *Woodfordia fruticosa, Ougeinia dalbergioides,* which also multiply by suckers, and grasses, chiefly the *baib* (*Eulaliopsis*). Unleached conglomerate soils are calcareous but when continuously leached they show neutral or nearly neutral reaction.

The strata of the conglomerate and clay alternate in these Siwaliks and very often a shallow layer of clay covering conglomerate occurs. In such soils, sal may be present but the undergrowth is predominently grassy. With the loss of the clayey layer by erosion sal is slowly disappearing as new regeneration survives

with difficulty on these soils. In such a situation the vegetation sometimes resembles a dry savanna. One such type was studied at Kansrao.

Among grassy undergrowth shrubs were mainly *Zizyphus* spp., *Carissa*, *Holarrhena*, *Ehretia*, etc. An odd old tree of *Adina*, *Terminalia belerica*, *Stephegyne* and even sal was found. But nowhere the regeneration of these species was found among grasses. Features of soil are given in appendix 1.

APPENDIX 1

Savanna vegetation at Kansrao in relation to pH and Ca content of soil

Profile No.	Locality	Depth in inches	pH	Calcium in m.e.	% loss on ignition	Vegetation
7	Savanna degraded sal forest on shallow soil with boulder on the surface	0	6·2	52·1	1·51	Chiefly *Zizyphus*, *Carissa* *Holarrhena*, *Ehretia*. Thick grassy undergrowth.
		6	6·2	56·8	1·41	
		18	6·3	48·6	1·00	
		24	6·3	51·1	1·91	
		36	6·2	53·6	1·98	
8	do.	0	6·7	37·9	3·42	Chiefly *Zizyphus*, *Carissa*. *Holarrhena*, *Ehretia*. Thick grassy undergrowth.
		6	6·7	37·9	1·91	
		18	6·6	36·4	1·90	
		24	6·5	32·9	1·08	
		36	6·3	33·2	1·20	
9	do.	0	6·4	23·9	3·75	*Zizyphus* 1, *Holarrhena* 12, *Mallotus* 6, *Carissa* 2, *Butea* 1. Thick grassy undergrowth.
		6	6·5	16·1	1·91	
		18	6·8	17·9	1·15	
		24	6·6	35·7	1·47	
		36	6·5	15·0	1·96	

These soils have usually low organic matter content and are dry. pH is near about the neutral point. Surface erosion, leaching and redeposition have brought together soils with varying amounts of Ca content. Lower layers of the soil, 6″ in one case and 24″ in another, recorded higher amounts of exchangeable Ca. Dryness of the soil is chiefly responsible for this feature.

In Ranipur Range conglomerate soils with or without a shallow layer of clay bear a mixed bamboo community. Trees of *Terminalia belerica*, *Lannea grandis*, *Holarrhena antidysenterica*, *Ehretia laevis* etc. pass through congested clumps of *Dendrocalamus strictus*. There is hardly any ground flora under bamboos except in open places where some stunted bushes of *Adhatoda vasica* are usually found.

The soil is a sandy clay with stones present at various depths. Features of the soil are given in appendix 2.

Here again there is a good deal of difference in exchangeable Ca in various soil profiles due to erosion and re-deposition phenomenon and accumulation at various depths.

APPENDIX 2

Soil features in relation to vegetation

Profile No.	Locality	Depth in inches	Calcium in m.e.	% N	% moisture content	% organic matter	R. H.	Vegetation
			Mixed bamboos community in Ranipur Range					
18	Ranipur Range	0	57·2	0·46	3·10	10·95	0·28	*Lannea grandis* 3, *Terminalia belerica* 1,
	Ranipur Beat	6	36·0	0·10	3·01	3·34	0·90	*Dendrocalamus*
		12	33·2		4·3	3·08	1·40	*strictus* 8 clumps
		24	32·4		3·4	3 10	1·10	*Adhatoda*
		36	38·4		2·75	2·82	0·98	
19		0	39 6	0·24	2·30	7·67	0·30	
		6	38·8	0·06	2·37	2·38	1·00	
		12	29·2		7·44	2·53	2·94	*Dendrocalamus*
		24	36·4		2·95	2·65	1·11	*strictus* 8
		36	30·0		3·37	1·94	1·74	clumps
20		0	34·2	0·15	1·82	6·90	0·26	
		6	39·6	0·001	2·12	2·48	0·85	
		12	32·8		1·72	2·57	0·67	*Dendrocalamus*
		24	32·4		2·26	1·99	1·14	*strictus* 6
		36	31·2		3·32	2·38	1·39	clumps
21		0	38·8	0·14	0·78	3·41	0·23	*Dendrocalamus*
		6	35·6	0·07	2·8	2·63	1·06	*strictus* 5
		12	38·2		1·93	2·48	0·78	clmups
		24	35·2		4·06	2·45	1·66	*Adhatoda* and
		36	40·0		7·21	2·76	2·61	a seedling of *Murraya koenigii*

Forest types on riverain habitats :

The strata of the Siwaliks formation in the area extend at places right upto the foot of the Himalayas on the north. The main rivers that arise from tne outer Himalayas cut through the Siwalik strata and tend to widen and deepen their beds every year. In addition innumerable nullas cut into these rocks and wash the debris down to lower levels. Along with erosion re-deposition of new soils takes place along water channels, which are colonised rapidly by different types of plants. These secondary deposits include boulder beds, shingle spits, coarse sands, finely divided sands, gravels, clays and silts.

The boulder beds and shingle spits are usually colonised by *Acacia catechu*, and in certain places where the proportion of clays and finely divided sand is more than the coarse material, a mixed community of *Acacia catechu–Dalbergia sissoo* is present. On bouldery soils, the *Acacia catechu* community persists but on finer sand and clays it is quickly replaced by *Holoptelea–Trewia* community which has a number of other species.

In deep clayey secondary soils with a high water table the forest develops into an evergreen type with at places, cane brakes and ferns.

On sandy banks along rivers only clumps of *Tamarix dioica* occur. These places are within the flood level of the river and regeneration of *Tamarix* is profuse in sandy moist soil.

Forest development is rapid on deep finely divided soils. On a sandy somewhat clayey soil at Motichur, a mixed *Trewia–Albizzia–Syzygium* community has developed. The vegetation here was characterised by the presence of large well developedt rees of the species given above. Here and there some trees of *Bauhinia* and *Dalbergia sissoo* were also present. In the second storey *Mallotus*, *Ehretia* and *Cordia* are usually found. In the shrub layer *Adhatoda*, *Murraya*, *Clerodendron* are usually present. Seedlings of *Syzygium* and shrubs were found here and there.

The soil has usually no stones in the profile, and does not show any stratification. Detailed chemical characters of the soil are given in appendix 3.

APPENDIX 3

Soil features in relation to vegetation

Profile No.	Locality	Depth in inches	Calcium in m.e.	% N	% moisture content	% organic matter	R. H.	Vegetation round 15 ft. of the soil profile
			Mixed riverain community in Motichur Range					
30	Motichur	0	60·7	0·20	3·39	9·39	0·36	*Mallotus* 3, *Cordia myxa* 1
	Range	6	60·1	0·09	5·07	5·80	0·87	
	Comptt. 6	12	59·4		2·89	4·00	0·72	*Aegle marmelos* 1
	Mixed	24	59·8		5·25	2·81	1·87	*Holarrhena* 1
	forest.	36	59·5		1·6	2·95	0·87	
31	do.	0	62·0	0·17	1·7	6·86	0·25	*Albizzia lebbek* 1
	Suswa Block 1	6	62·3	0·05	2·63	4·75	0·55	*Cordia myxa* 1
		2	61·6		3·75	5·39	0·70	*Dalbergia Sissoo* 1
		24	60·6		3·12	2·89	1·08	*Murarya koenigii* 1 shrubs
		36	66·0		4·55	6·30	0·72	*of Adhatoda.*
32		0	61·8	0·15	2·75	9·29	0·30	*Albizzia lebbek* 1
		6	61·6	0·09	3·76	6·45	0·58	*Anogeissus* 1
		12	62·8		6·0	6·43	0·93	*Mallotus* 2
		24	61·2		4·15	3·42	1·21	*Bauhinia variegata* 1 shrubs
		36	61·8		2·98	5·60	0·53	*Adhatoda*

Profile No.	Locality	Depth in inches	Calcium in m.e.	% N	% moisture content	% organic matter	R. H.	Vegetation
33		0	62·0	0·10	1·0	7·14	0·14	*Trewia nudiflora* 1
		6	63·4	0·02	0·37	4·55	0·08	*Syzygium cumini* 2
								Ehretia laevis 2
								Holarrhena 2
								shrubs of *Ad-*
		12	62·2		4·87	6·51	0·75	*hatoda*
		24	61·6		1·32	4·11	0·32	*Clerodendron* seed-
								lings of *Syzygi-*
		36	61·4		3·05	4·65	0·66	*um cunini*
34		0	60·0	0·22	3·02	11·57	0·26	*Ehretia laevis* 1
								Mallotus 2
		6	59·5	0·11	3·39	4·49	0·76	*Murraya koenigii*
								1, *Ricinus com-*
		12	61·2		1·8	1·89	0·95	*munis* 3, shrubs
		24	60·6		2·7	2·44	1·11	and seedlings
		36	61·0		1·16	3·12	0·37	of *Adhatoda.*
35		0	61·4	0·24	1·86	10·44	0·18	*Trewia nudiflora* 5
		6	60·6	0·03	0·42	3·39	0·12	*Ehretia laevis* 3
								Cordia myxa 1
								shrubs of *Adha-*
		12	59·6		1·24	3·40	0·36	*toda.*
		24	60·0		2·29	2·37	0·68	*Murraya koenigii*
		36	60·0		2·95	2·38	1·24	
36	Motichur Range	0	62·0	0·37	6·37	14·01	0·45	*Trewia nudiflora* 1
	Comptt. 7							*Syzygium cumini* 1
	Suswa	6	62·6	0·10	3·53	4·60	0·77	*Mallotus* 3, *Cole-*
	Block	12	62·0		4·23	4·08	1·04	*brookia* 5, shrub
								of *Adhatoda,*
		24	62·4		3·12	3·44	0·91	*Murraya koenigii.*
		36	61·8		3·27	2·40	1·36	
37	do.	0	62·9	0·40	5·8	13·83	0·42	*Sterculia urens* 1
								Mallotus 2
		6	67·6	0·10	2·65	3·71	0·71	*Trewia nudiflora* 1
								Albizzia lebbek 2
		12	61·9		2·55	3·42	0·74	*Murraya koenigii* 1
		24	62·0		2·88	4·08	0·71	shrubs of *Adha-*
		36	61·4		8·0	8·74	0·92	*toda.*
41	do.	0	44·8	0·35	8·65	11·73	0·49	*Syzygium cumini* 3
	Mixed							*Mallotus* 5
		6	27·6	·10	5·40	4·86	1·11	*Putranjiva,* 1 seed-
		12	30·2		3·80	3·98	0·95	lings of *Putran-*
		24	30·4		2·60	4·97	0·52	*jiva, Mallotus,*
		36	43·2		2·40	5·53	0·43	*Murraya.*

APPENDIX 4

Riverain community in Suswa Block of the Motichur Range

Profile No.	Locality	Depth in inches	Calcium in m.e.	% N	% moisture content	% organic matter	R. H.	Vegetation
38	Motichur Range Suswa Block Comptt. 7 Moist riverain with canes.	0	72·4	0·28	7·15	7·65	0·93	*Sterculia urens* 1 *Holoptelia integrifolia* 1
		6	70·6	0·16	8·45	4·20	2·01	*Putranjiva* 2
		12	66·8		11.95	3·91	3·06	*Randia dumetorum*1 seedlings of
		24	62·6		17·75	3·58	4·96	*Syzygium cumini*
39	do. Mixed forest dense cane.	0	74·2	0·34	6·25	10·18	0·61	*Mallotus* 2 *Holarrhena* 1 seedlings of *Putranjiva*
		6	33·4	0·12	6·60	4·92	1·34	
		12	76·4		11·50	4·74	2·42	
		24	51·6		16·45	5·98	2·75	
		36	25·6		21·9	4·22	5·19	
40	do. cane	0	43·6	0·32	5·35	7·87	0·68	*Trewia nudiflora* 2, *Cordia myxa*1,
		6	29 8	0·10	6·8	3·7	1·84	*Syzygium cumini* 1, *Holarrhean* 2,
		12	30·4		5·85	3·45	1·70	*Mallotus* 2, *Putranjiva* 1 seed-
		24	82·4		17·05	9·22	1·85	lings of *Mallotus*
		36	41·4		15·55	8·88	17·5	*Cordia dichotoma*
42	do. cane	0	34·0	0·27	10·0	10·49	0 95	*Cordia dictotoma* 2,
		6	29·0	0·11	7·2	4·63	1·55	*Putranjiva* 5 seed-
		12	29·9		12·2	6·26	1·95	lings of *Clerodendron Mallotus*
		24	32·3		6·15	2·45	2·51	
43	Motichur Range Suswa Block Comptt. 7 cane	0	33·3	0·21	3·25	9·40	0·35	*Syzygium cumini* 1 *Ehretia laevis* 3
		6	29·1	0·09	3·50	3·52	1·00	*Putranjiva* 1, *Mallotus* 1 seedlings of *Clerodendron*,
		12	24·6		3·75	3·27	1·15	*Putranjiva, Murraya, Syzygium*
		24	23·4		0·55	3·82	0·14	
		36	21·2		0·20	1·60	0·125	*cumini, Mallotus*
44	do.	0	44·2	0·26	8·75	11·28	0·78	*Trewia nudiflora* 1 *Putranjiva* 1 seedlings of *Clerodendron, Adhatoda,*
		6	36·5	0·21	14·45	6·25	2·31	
		12	31·9		21·2	5·07	4·10	*Syzygium cumini*
45	Motichur Range Seswa Block Comptt. 7 cane.	0	46·4	2·29	3·95	9·73	0 41	*Grewia elastica* 2 *Mallotus* 1 shrubs
		6	33·0	0·28	5·5	5·92	0·93	of *Adhatoda, Clerodendron*, seedl-
		12	31·6		3·55	3·47	1·2	
		24	32·8		2·3	2·71	0·85	ings of *Putranjiva,*
		36	33·8		4·5	6 23	0·72	*Murraya koenigii*

In the Suswa Block of Motichur Range the mixed riverain community has more of *Syzygium* and a large number of trees of *Putranjiva*. The crop here is much more dense and in addition to the middle storey and shrub layer species described for the above community, the remarkable feature here is the presence of cane brakes. There is a profuse regeneration of *Putranjiva* at most places.

The soil here has a higher proportion of clay and the water-table is generally high. In one or two profiles water-table was faund at the depth of one foot 5 inches. In one or two profiles stones were found àt different depths, mostly below 2 feet. Roots were present in almost all the profiles to a depth of 36 inches. In some of the profiles studied where water level was high, roots were generally not found in the water layer. The upper layer of the soil in some cases was slightly blackish in colour showing higher amounts of organic matter. Detailed soil properties are given in appendix 4.

In Chandnava block of Barkot Range an old heavily disturbed community of *Dalbergia-Holoptelea* was studied. The old trees have been felled and numerous shrubs of *Murraya*, *Aegle*, and *Cassia fistula* were present. There were also shrubs of *Zizyphus*. There was no regeneration of any of the riverain species and a dense cover of grasses and *Cassia tora* was present.

The soil here was somewhat coarse and sandy, mixed with small stones and gravel. It has been cosiderably leached due to frequent flooding. Soil organic matter was also low. Stones were found in all the three profiles at a depth of 12 inches. The detailed characters of soil are given ip appendix 5.

APPENDIX 5

A heavily disturbed riverain community in Barkot Range

Profile No.	Locality	Depth in inches	Calcium in m.e.	% moisture content	% organic matter	R. H.	Vegetation
49	Barkot Range Chandnava Block Comptt. 2 Mixed forest	0	36·8	0·35	2·25	0·16	*Zizyphus*
		6	31·6	2·0	3·57	0·56	*jujuba* 3
		12	28·8	1·05	2·51	0·42	
		24	27·8	1·25	3·25	0·38	
		36	27·2	2·0	3·0	0·66	
50	do.	0	31·0	0·80	5·04	0·16	*Holoptelia integri-*
		6	30·4	1·54	2·18	0·71	*folia* 1 *Murraya*
		12	30·2	2·72	3·2	0·83	*keonigii* 2 seed-
		24	30·8	11·95	13·84	0·86	lings of *Murraya*
		36	32·8	1·87	2·89	0·65	*koenigii*
51	do.	0	36·6	1·92	8·74	0·22	*Cassia fistula* 1
		6	29·2	1·70	2·89	0·59	*Dalbergia sissoo* 1
		12	—	1·82	2·24	0·81	*Agegle marmelos* 2
		24	30·2	3·89	3·64	1·07	shrubs and seed-
		36	31·6	2·37	2 76	0·86	lings of *Murraya koenigii*
52	do.	0	34·4	1·75	8·18	0·21	*Holoptelia integri-*
		6	31·2	2·3	5·52	0·44	*folia* 2 *Dalbergia*
		12	32·8	1·9	4·81	0·39	*sissoo* 1 seedlings
		24	35·0	4·0	6·58	0·61	of *Murraya koengii*
		36	32·4	3·9	5·00	0·78	

Riverain forests at Ranipur are developed on an old riverain deposit, which is being eroded now and again. The soil is sandy with a fair amount of clay. Stones are present at the surface as well as at various depths. The soil has become hard and compacted as a result of grazing.

The vegetation is opon, consisting of a mixed deciduous community of *Acacia catechu, Dalbergia sissoo, Lannea grondis, Adina cordifolia, Atbizzia procera* in which *Dendrocalamus strictus* and teak have been planted. Here and there *Bombax, Bauhinia Zizyphus, Casearia tomentosa* etc. are present. In the lower storey there are *Murraya, Adhatoda, Cassia tora* and scattered clumps of *Saccharum.* Detailed soil features of this community are given in appendix 6.

APPENDIX 6

A mixed riverain community at Ranipur Range

Profile No.	Locality	Depth in inches	Calcium in m.e.	% N	% Moistur content	% organic matter	R. H.	Vegetation
26	Ranipur Range Ranipur Beat	0	65·3	0·26	2·06	0·34	0·28	*Salmalia malabarica*
		6	60·7	0·07	3·09	3·75	1·04	1, *Zizyphus jujuba*
		12	62·0		3·9	2.91	1·34	1, *Ehretia laevis* 2
		24	62·4		3·1	2·43	1·28	shrubs of *Adha-*
		36	61·1		3·9	2·65	1·47	*toda* seedlings of *Murraya koenigii.*
27	do.	0	62·7	0·16	1·75	5·49	0·32	*Casearia tomentosa* 2,
		6	60·8	0·03	1·60	3·91	0·41	*Aegle marmelos* 1,
		12	60·2		4·15	2·23	1·28	*Bombax malabaric-*
		24	60·2		3·05	2·53	1·21	*um* 1 shrubs of
		36	60·6		2·75	2·26	1·22	*Adhatoda, Murraya koenigii, Achyranthus aspera, Carissa spi-narum*
28	do.	0	63·4	0·26	2·8	9·77	0·29	*Salmalia malabarica*
		6	61·8	0·003	2·2	2·25	0·98	1, *Dendrocalamus*
		12	61·0		2·25	1·84	1·2	*strictus* 4 clumps
		24	61·2		1·35	1·62	0·83	
		36	61·6		1·60	1·73	0·92	
29	do.	0	60·4	0·13	1 0	6·20	0·16	*Tectona grandis* 2,
		6	61·0	0·05	1·75	2·23	0·78	*Salmalia malabarica*
		12	90·2		1·73	1·92	0·90	1, *Dendrocalamus*
		24	59·4		2·03	2·09	0·97	strictus 3 clumps
		36	59·0		2·09	2·02	1·03	shrubs of *Casearia tomentosa*

On compacted and somewhat clayey soils, which tend to become water-logged the riverain cnmmunity has *Butea monosperma.* Studies were made of these patches. These soils have generally no stones. Detailed soil and vegetation features of this community are given in appendix 7.

APPENDIX 7

Mixed riverain community with Butea in Ranipur Range

Profile No.	Locality	Depth in inches	Calcium in m.e.	% N	% moisture content.	% Organic matten	R.H.	Vegetation.
22	Ranipur Range RanipurBeat Mixed riverain forest	0	37·6	0·36	3·07	14·4	0·21	*Butea monosperma* 1
		6	22·8	0·07	3·31	3·38	0·98	*Lannea grandis* 1
		12	23·0		4·24	3·18	1·33	shrubs of *Adhatoda*,
		24	23·6		12·35	2·17	5·69	*Carissa spinarum*,
		36	25·8		1·2	1·36	0·88	*Cassia tora* seedlings of *Albizzin* and *Carissa*
23	do	0	29·0	0·33	18·15	6·84	2·65	*Adina cordifolia* 1
		6	23·8	0·06	0·18	2·50	0·72	*Casearia tomentosa* 2
		12	25·0		11·86	4·23	2·80	shrubs of *Adhatoda*
		24	59·0		14·70	4·10	3·59	*Saccharum*, *Abrus*
		36	40·0		14·21	8·40	1·69	seedlings of *Adhatoda*
24	do	0	32·7	0·50	5·05	10·2	0·50	*Acacia catechu* 1 *Butea monosperma* 2
		6	21·7	0·09	4·8	2·78	1·73	saplings of *Carissa* and *Carissa fistula*
		12	21·5		5·0	2·53	1·98	Dense cover of
		24	27·3		9·55	3·76	2·54	*Adhatoda*
		36	26·3		13·35	3·52	3·79	seedlings of *Murraya*, *Albizzia*
25	do	0	28·0	0·30	3·4	9·73	0·349	*Acacia catechu* 1 *Casearia tomentosa* 1
		6	24·7	0·05	2·6	1·80	1·44	*Butea monosperma* 1 Fairly close
		12	19·8		2·45	1·18	2·08	*Adhatoda*, *Zizyphus Murraya*
		24	19·6		1·65	1·47	1·12	*Saccharum* 4 clumps seedlings of
		36	20·2		3·50	2·58	1·36	*Zizyphus*.

Soil and plant relationship :

In an earlier study (Puri, 1950) a relationship between pH classes and plant communities was found in some forest types of the Dun Valley. This relationship showed overlapping in pH as was found in the case of vegetation.

The soil pH and some plant communities are tabulated below :

Vegetation and habitat	No. of soil samples	pH CLASSES 4·5–5·0	5·1–5·5	5·6–6·0	6·1–6·5	6·6–7·0	7·1–7·5	7·6–8·0	8·1–8·5
	Number of soils in each pH class								
Sal-Eugenia old crop (clays) 4	75	1	11	47	14	1	–	–	–
Mixed Sal-*Syzygium* (clay) 6	25	–	–	9	14	2	–	–	–
Sal-heavily disturbed dry clay 5	15	–	–	4	10	1	–	–	–
Sal coppice crop clay 2	19	–	–	3	11	2	3	–	–
Sal PB Inter clay 3	20	–	–		8	4	1	–	–
Sal-*Terminalia* clay 7	25	–	–	–	18	7	–	–	–
Moist Savanna conglomerate 12	15	–	–	–	7	8	–	–	–
Open mixed savanna scarp 11	45	–	–	–	18	8	12	6	1

It shows that clayey soils on the whole have a low pH value. The widest range of pH was found in the case of old Sal-*Syzygium* crop, with majority of soils in below 6·0 pH. In sal communities disturbance to the crop or soil brings in an increase in soil pH. The highest pH values were found in open savanna type of vegetation, especially on conglomerates and scarp slopes. The feeble relationship between soil pH and plant communities is due to the intense biotic interference even in the best type of plant communities.

Succession of Forest Communities on the clay and conglomerate :

The clay bears sal forest with a little admixture of other species and an evergreen shrub layer. Under the existing physical and biotic influences of the environment it is a fairly stable community, showing ample regeneration of component species. On somewhat dry clay, the percentage of sal in the crop, however, may be less and the community may be sal-*Terminalia* and/or sal-*Terminalia-Anogeissus*, with a little or no shrubby layer, but a highly developed ground layer of grasses. This community is more common on dry clay along the scarp slope, especially if it coincides with a southern aspect and may also be found on mixed sandy and clayey soils, which are dry. This forest is natural, though its composition and physiognomy may have been influnced by fire, grazing, lopping etc.

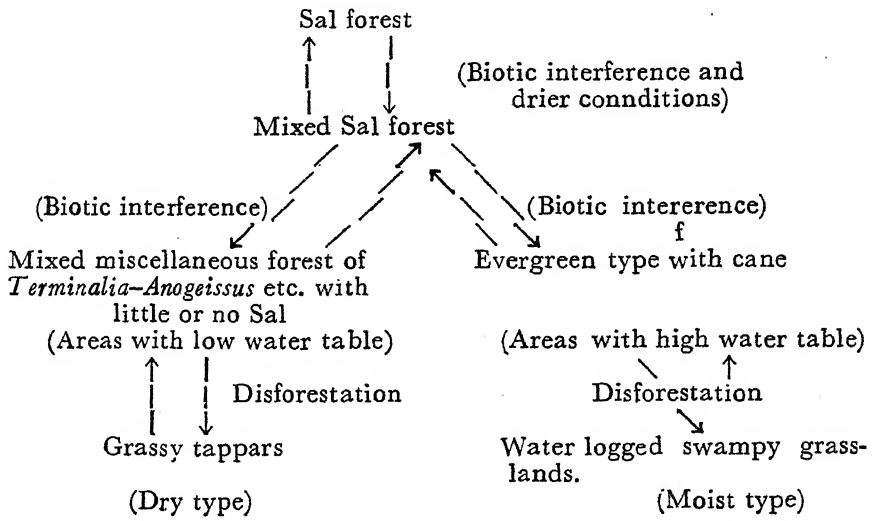
On dip slope and where the soil is moist, the forest community is dominated by sal which is almost pure or may have a certain percentage of *Lagerstroemia parviflora* and *Syzygium cumini* in the upper canopy. The second storey species include *Litsaea*, *Phoebe*, *Mallotus*, *Careva*, etc. There is a poorly developed grassy layer but *Adiantum*, *Oplismenis* and some broad leaved ground species are usually common. This community shaped by forest management practices is stable and shows regeneration.

The dry type of sal forest degrades into a grassy savanna of the dry type and the moist type of sal forest into a swampy type with little or no trees and a luxuriant growth of grasses. These savannas may thus be comparable to post-climax types of which the climax is a mixed moist deciduous forest described by Champion (1933).

In the two types of sal forest the pioneer species are usually the *Terminalia Anogeissus*, *Lager stroemia Syzygium*, etc., and sal is comparatively a late arrival.

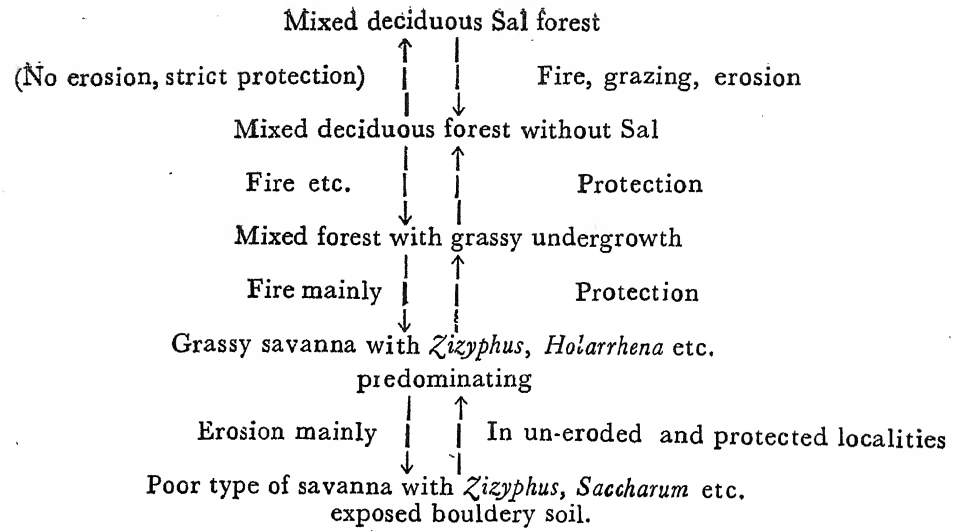
The degradation of the two types of sal forests into the two types of Savanna is no doubt influenced by forest clearing and other unfavourable biotic practices and it is almost impossible in most cases to take the savannas into their original sal forest by removing the inhibiting biotic causes. This is due to the fact that forest clearing makes the dry type of clay soils more dry and the moist type of clay soil more moist and even wet. In the former case the water table is lowered and in the latter water table becomes higher. The dryness of the climate in both cases sets in evaporation from the soil, bringing dissolved salts to top layers of the soil. In both cases good forest soil gets converted into an Usar or Kallar type. The reclamation of such soil involves flooding which unfortunately bring about intense erosion. Thus erosion and the change of soil conditions after forest disturbance makes the progress of secondary succession to a forest stage and extremely difficult proposition. In actual practice, therefore, large stretches of savanna which were at one time good sal forest have come to stay and give the appearance of a stable community.

The succession of forest communities on deep clayey soil, occuring on dip slope and/or north aspect is summarised below :



On conglomerate, sal may or may not be present and the forest may be composed of predominately deciduous associates of sal with a well developed grassy undergrowth and a second storey of *Casearia* spp., *Ficus cunia*, *Kydia calycina*, etc. This type of forest is a stable type on conglomerate and its degradation into a grassy savanna is likewise aggravated by the biotic factors.

The succession of forest communities on conglomerate or/and on sandrocks occurring on scarp and south aspect is given below :



A sal forest and a mixed deciduous forest without sal may alternate on the same site depending upon whether clay or the conglomerate is exposed on the surface. In such a case it may appear that the sal forest has progressed or retrogressed to a mixed deciduous forest without sal. But as explained above sal forest even though it progresses or retrogresses does contain a certain percentage of sal trees. The dry type with a higher percentage of associates of sal and the moist type with a higher percentage of evergreen sal associates may be considered a stable community in the area on the Siwaliks.

Forest succession in Riverain habitat :

On riverain habitats a number of soil types are found. These range from boulder beds, gravel, shingle spit, coarse and fine sandy soils and silts. On most of these the new tree species to appear are *Dalbergia sissoo, Acacia catechu, Tamarix articulata,* etc. The succession of the initial community progresses differently depending upon the potentiality of the site and the biotic factors at play. In areas which are raised from the level of the river and there is no danger of monsoon floods, the *Dalbergia–Acacia* community progresses rapidly. The sequence of succession indifferent riverain habitats is given below :

1. *Boulder bed.*

Dalbergia sissoo or/and *Acacia catechu* remains more or less stable community. The underground species may be *Adhatoda vasica* or *Zizyphus, Holarrhena,* the boulder bed is located in originally forest habitat. The *Zizyphus, Holarrhena* and other species like *Adina, Terminalia,* Sal, which may be present are remnants from the original forest habitat which has been modified by erosion or deposition.

2. *Gravel, Shingle spit etc.*

The *Dalbergia–Acacia* community on such types of soil progresses to *Trewia-Holoptelea* community which seems to form an open type of forest, different species regenerating more or less adequately.

3. *Sandy, somewhat saline soils.*

On these *Tamarix articulata* forms almost pure communities in the bed of the river or along stream banks. This community may have *Vitex negundo* or one or two other species and tend to remain more or less stable so far soil is not washed away.

4. *Silty soils.*

These soils have very great potentialities for rapid succession of forest communities. The pioneer *Dalbergia–Acacia* community progresses to *Trewia–Holoptelea* in which a number of evergreen species like *Syzygium* come in. These form sometimes dense forests.

SUMMARY

The succession of forest communities occurring in mixed deciduous forests of Dehra Dun and Saharanpur forest divisions have been studied by the quadrat method. The area being apart of the Siwalik hills is composed of alternating layers conglomerate and clay to which strata of sandrock are interbedded at some places. The forests on the clay are predominantly composed of *Shoreea rubusta* whereas those on the conglomerate contain deciduous species. Both these types suffer from intense biotic disturbances of an organised and irregular nature.

The succession on both clay and conglomerate have been studied in detail under the existing conditions of the environment.

Forest communities on the different types of riverain habitat have also been studied in detail and their successional trends indicated.

The soil features for each community have been studied in profiles and data have been presented in tabular forms. Since the forest communities studied have been very greatly disturbed by the biotic factors, including systematic forest management, silvicultural operations, controlled grazing, burning and lopping as expected no clear correlation between detailed factors of the soil have been obtained. However, pH of the soil and exchangeable Ca show a feeble positive correlation. pH and loss on ignition has also a little relationship. But those relationships have been disturbed by fire, grazing, felling and other biotic interferences.

REFERENCES

Champion, H. G. 1933. Regeneration and managemens of sal (*Shorea rubusta*), *Ind. For. Rec.*, **19** : 1–155.

Puri, G. S. 1949. The ecology of erosion and landslips, *Ind. Geog. Journ.* **24.**

———1950. Soil pH and forest communities in the sal (*Shorea rubusta*) forests of the Dehra Dun valley, U. P., India, *Ind. For.* **76** : 292–309.

Sahay, R. 1951. Working Plan for the Dehra Dun forest division, 1949–50 to 1958–59, **Allahabad.**

Srivastava, T. N. 1951. Working Plan for the Saharanpur forest division, 1952–53 to 1958–59, **Allahabad.**

SOCIAL-ECONOMY OF THE HIMALAYAN PEOPLE IN RELATION TO THE FORESTS OF GARHWAL HIMALAYAS

By

RAJ KUMAR GUPTA

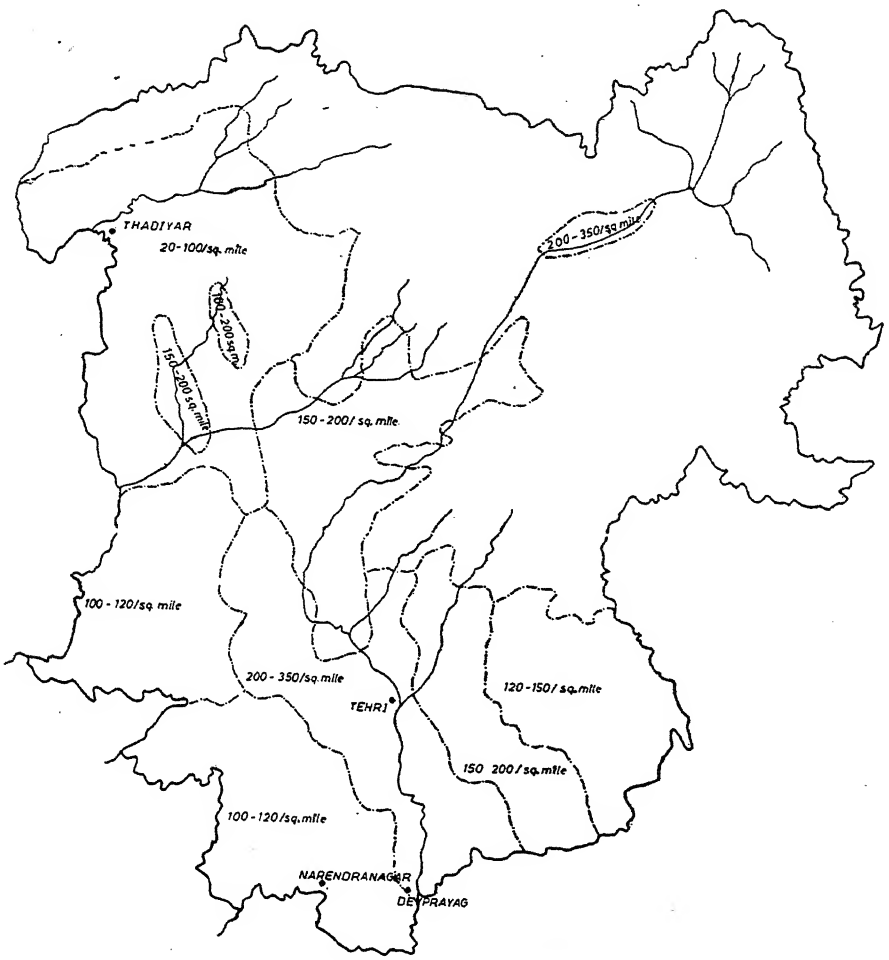
French Institute, Pondicherry

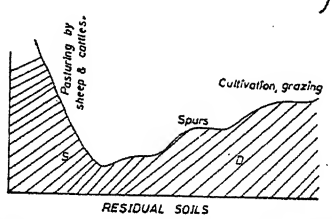
The Himalayas are extremely important to India, not only geographically, but economically their importance has recently been recognised. The entire economy of the Indo-Gangetic plain depend upon the socio-economic stability the Himalayan people. In order to bring fertility to the plains and to utilise in a proper way the flood waters of the Himalayas, it has been considered necessary to build dams and multi-purpose valley projects for irrigation, hydro-electric power, flood control and for other numerous beneficial effects of these natural resources it has been abundantly stressed that mere construction of these dams would not confer the benefits that are desired, but in order that silting of these man-made reservoirs could be reduced the Himalayan structure need necessarily be under vigilance. Sometimes the Himalayan slopes become unstable due to earthquake, landslide, landslip caused by defforestation and abuse of land or natural features such as unstable topography, unstable dips and rainfall ; whatever may be the cause of silting and erosion, it is always necessary to find out the relation of this feature with the vegetation. With this object in mind studies on the vegetation of Garhwal Himalayas were started by the author, at the suggestion of Dr. G. S. Puri, in continuation towards east of the region, in Kulu and Bashahar, already studied by Puri and his associates (1950, 1954).

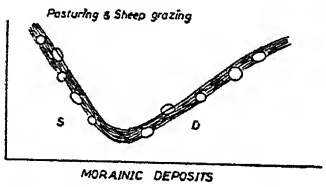
The Himalayas are rich in timber and medicinal herbs. The Himalayan pastures are considerably luscious for cattle and sheep. Himalayan people have peculiar socio-economic conditions. All these are intimately related to the plant cover. Himalayan people are mainly agriculturists and depend on the forests, for their everyday requirements. Clearing of forests for making new fields, cutting for timber and fuel ; lopping for fodder and thatching houses and cattle-shed go without rule near the hutment and villages. Valleys of river Ganga and Yumna (called Gagar areas) are most fertile and cultivated extensively for paddy and other crops. Fields on gentle slopes are not well terraced and constitute a regular danger of the soil being washed away with the rains. Shifting of cultivation is a regular practice and the fields are abandoned when cultivated for 2–3 years. On steep slopes fruit trees are cultivated near the villages. All these factors are indirectly or directly related with the plant cover. The socio-economic conditions are such that the forests have become a part and parcel of the daily life of Himalayan villager.

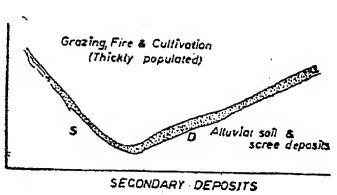
In these pages a brief survey of the socio-economic conditions of the Himalayan people, have been attempted in relation to the forest vegetation of the area. Suggestions for the improvement of the area without disturbing the economy of the inhabitants have been made with a view to reduce pressure on the land.

MAP OF TEHRI GARHWAL SHOWING THE DENSITY OF POPULATION AND ITS RESULTS ON THE DIP AND SCARP SLOPES









Population :

Gorrie (1938) has given an excellent account of the effect of population and misuse of land in Punjab. It has been recorded that in the Garhwal Himalayas (Tehri Garhwal, an erstwhile princely state lying between lat. 30°3′ and 36°18'N. and long. 77·53 and 79°28 E.) most of the areas especially in the valleys of river Ganga, Yumna and Tons are thickly populated. The average population is about 27 inhabitants per Sq. Km. The southern parts have an average of about 50 inhabitants per. Sq. Km.

Cultivation :

Flood plain deposits in the valleys of river Ganga, Yumna and Tons are the ideal places for cultivation ; the following three zones have been marked by Heske 1931 :

(*i*) below 1200 m. above the sea level in sub-tropical areas in the valleys of the rivers where two and possibly three harvests can be done.

(*ii*) between 1200–2000 m. on the level between the sub-tropical and temperate climate where only two harvests are possible.

(*iii*) between the regions of evergreen oak forests above 2000 m. where one harvest is possible.

In the first zone two crops 'Rabi' and 'Kharif' are harvested. In irrigated areas paddy is cultivated while in unirrigated areas wheat and paddy are sown besides other cereals such as '*Jhingora*', '*Bajra*', '*Mandua*' and different spices. In the second zone rice is the chief produce and is sown, pure or mixed with *Seasmum* while in the third '*Marsa*' (*Amaranthus* sp.) with Paddy crop is cultivated.

During the regime of the erstwhile Maharaja the entire land belonged to the state, the population having only the rights of rent. After the payment of a sum called *Najrana* the land could only be acquired by the descendents of a man after his death which was used to be fixed according to the quality of soil and the number of Nalis.* So new agricultural fields could only be brought by forest clearing.

The position of irrigation in the district is interesting. Some fields are irrigated, by the rivers and rivulets while others are dependent on local thunderstorm rains. Sometimes the rains are too much so that the entire terraced fields are washed away and brought to ruin. This aspect is seen in those valleys whose top have been defforested and are lying eroded ; there the water is not retained and the soil and rain water flows down quitely without being absorbed in the soil. If there is a dry period during the months of July to September famine condition results.

The agriculture in the district is just sufficient to satisfy the limited requirements of life of the inhabitants. The economic resources are such that the villagers have to depend on agriculture and if he does not have sufficient land, has to migrate to the plains and work as domestic servants, coolies, rickshaw pullers, etc. Therefore a villager in the Himalayas is always in demand for the land and whenever there is any possibility (even on steep slopes by terracing) he tries to utilise the same with a great difficulty.

*Local measurement of land.

The aim of right forest policy would therefore be not only to protect the forests from slow destruction by the ignorant agricultural population but also introduce some agricultural reforms and afforestation of denuded and eroded slopes by planting appropriate trees.

Grazing :

The Garhwalis are mostly cattle grazers and with their cattle, goats and sheep they go inside the forests and clear them for making temporary sheds for their cattle and for fodder. The population is mostly of Hindus and 5 animals (1 pair oxen and 3 cows) for a house on the average are considered essential. Though the milk supply of an average cow is 2–3 litres daily as compared to 16–20 litres in the plains, cattle are kept for agricultural use.

Above 2500 m. grazing by the sheep and goats is frequent. These are kept as (1) transport animals and (2) for getting wool and meat.

During winter Jad and Bhutia traders come down on the plains and sell their goods like wool, aconite, *Nardosachys* and other medicinal herbs and take with then salt, Jaggary, oil and other commodities on their return journey. During this process they use their animals. for transport since the path leads over steep mountain slopes, deep ravines, and gorges. Harsil (in the Bhagirathi Ganga valley) is the home of Jad traders where they are settled and come down to Dunda (1000 m. approx.) and even to the plains of north India during winters.

These shepherds carry articles on the back of sheep and goats in small girdles made from skin and travel 8–12 km. in a day. After reaching their camp they let loose the herds and allow them to graze in the nearby forests. Large herds of sheep and goats can be seen going towards Bhagirathi valley where there are Cedar forests without any rejuvination.

A nomadic tribe called 'Guzars' keep big herds of cattle and their main occupation is pasturing. During late summers they obtain permits from the forest department on payment of nominal charges and enter the forest areas at high altitudes where they make temporary huts for themselves and for their cattle. The alpine grassland and herbaceous plants provide fodder for their cattle. In early winters they come down to the plains and in the foot hills of Dehra Dun and Rishikesh where they live for the winters and destroy the forest vegetation.

The following tables 1 and 2 show the number of kinds of animals allowed grazing free and/or on payment by the forest department in Tehri Forest Division (being an average of 10 years).

TABLE 1

Showing the number of kinds of animals of villagers permitted for grazing.

	No. of house hold	Buffaloes	Cows and Buffaloes	Sheep	Goats	Mules	Ponies
Bhillanga	7341	12095	25087	13511	6798	30	57521
Alakhanda	12444	13572	36393	6159	12367	109	68600
Tehri	16296	19163	33983	7578	15707	494	76925
Shivpuri	10003	12810	61345	5740	28171	691	117575
Total	46084	57640	156808	32988	63043	1324	320621

TABLE 2

Showing the number of kinds of animals allowed grazing on payment (being an average of 10 years).

Range	Buffaloes	Cows and Buffaloes	Sheep and Goats	Mules
Bhillangna	30	2	200	2
Alaknanda	45	8	850	8
Tehri	30	2	200	2
Shivpuri	544	489	300	34
Total	649	501	1550	46

Cutting and lopping :

The villagers employ old methods for the cultivation and are dependent on the forests for their agricultural implements, fuel, charcoal and other daily requirements. Trees near the settlements are heavily lopped and die without any rejuvination. Villagers do not go far into the forests for their requirements and destroy the neighbouring vegetation completely ; when they are not able to get any supplies from the neighbouring areas, they go to the nearest forest and destroy it. This practice is still prevalent ; the monsoon forests in the foot hills and the oak forest show clearly the effects of cutting and lopping, where from a distance most of the forests can be seen in distinct strips ; the lower ones degenrated into bushy growth and the upper still left in a somewhat flourishing condition.

Leaves are lopped for the following purposes :

(1) Fodder for the cattle—Leaves of *Bauhinia, Rhus* and oaks (*Quercus incana, Quercus dilatata* and *Quercus semecarpifolia*) supply excellent fodder and to this end the trees are heavily lopped. During the dry period when the fodder is not available the leaves are stored.

(2) As green manure—Leaves when mixed with cow dung are kept for some time and used as green manure in the fields for at least twice in a year.

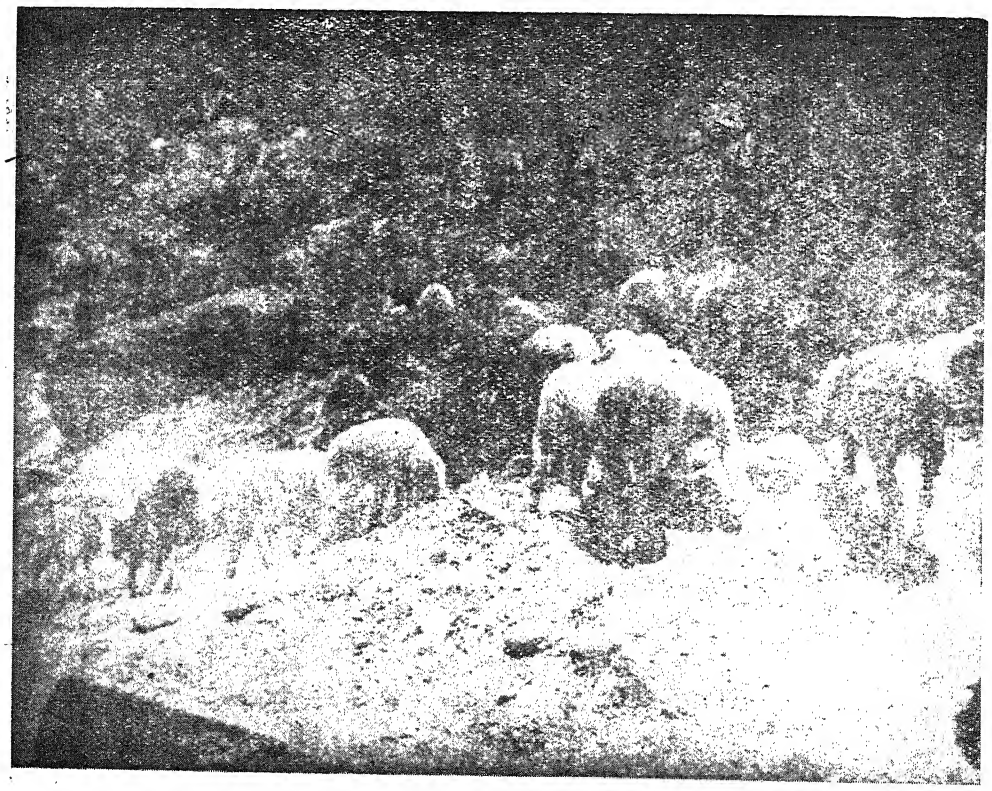
(3) Thatching houses and making floor for the cattle—Leaves when spread on the floor in cattleshed keep them warm and so employed extensively. Temporary shed for cattle and the inhabitants are made from the branches and the leaves of the trees.

As long as a tree is able to supply leaves it is lopped which ultimately dies and used for burning. The way in which neighbouring slopes near the villages are denuded can be seen near the Ganga, Yumuna and Alakanda valley ; only poor shrubby growth in humid river valleys can sometimes be found.

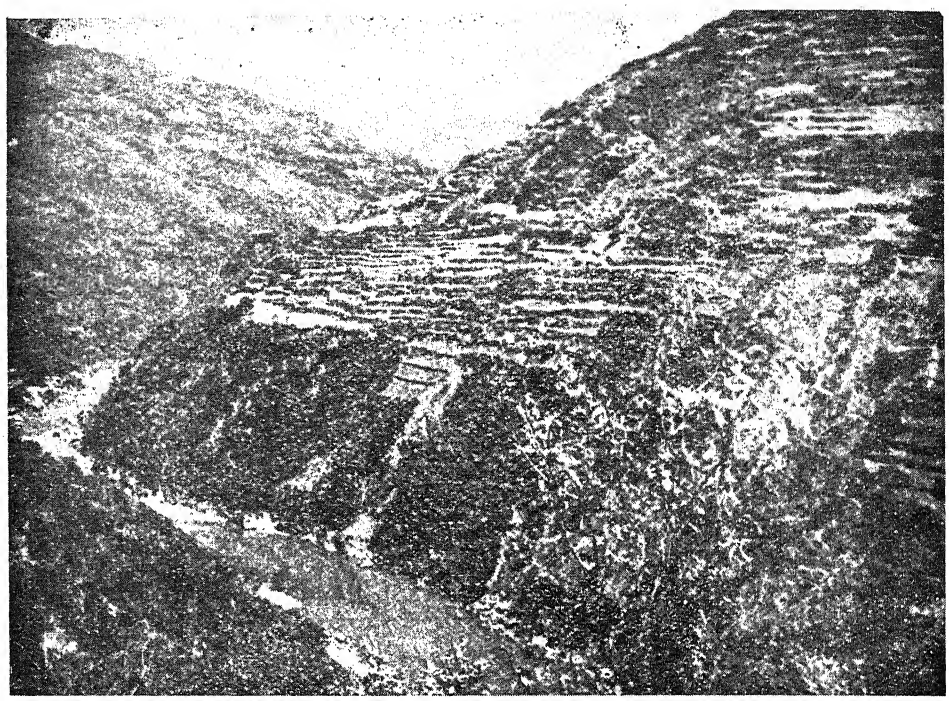
Fires :

In the coniferous forests, especially *Pinus roxburghii*, fires are most frequent and often intentionally set by local villagers for the luxuriant growth of grass in *chir* forests. As the undergrowth in these forests is very sparse, perhaps on account of the acidic nature of the fallen dried needles, nearby villagers have to go far for grazing their animals. Moreover the dried needles are slippery and consitiute a regular danger for the cattle.

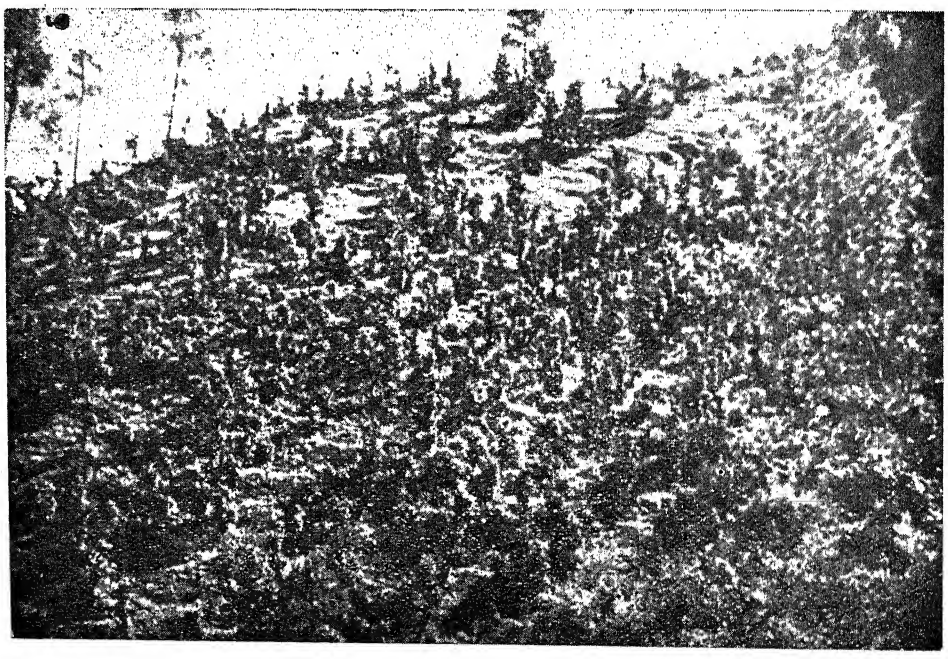
1. A lopped up tree of *Bauhinia* in The Bhagirathi Ganga valley.



2. Grazing by the sheep of Jad and Bhutia traders in the coniferous forests of Bhagirathi valley.



3. Terrace cultivation on steep slopes in Alaknanda valley.



4. A degenerate community of Oak scrub showing the invasion of conifers from above.

The effect of fire on these forests have been variously discussed by Champion (1919, 1936), Osmaston (1920, 1922), Dudgeon and Kenoyer (1925), Mohan (1933) and Puri (1955).

Champion considers these forests to be the 'climatic climax' while Dudgeon and Kenoyer believes that they are '*Xerophytic edaphic* climax stage' in the broad leaved sclerophyll formation of oaks. Mohan and Puri (1955) while working on the *chir* pine forests of Punjab and Himachal Pradesh have shown that *Pinus roxburghii* forests be regarded as edaphic climax. Osmaston (1922) is of the view that *Pinus roxburghii* and *Cedrus deodara* forests are held to exists when certain edaphic factors operate to maintain it permanently below the general climatic climax for the region. According to him the determining factor is the scarcity of soil water due to physical dryness.

Studies on the dip and scarp slopes by Puri and his associates in Punjab and Himachal Pradesh (lc.) and in Garhwal (Gupta 1959) have already revealed that *Pinus roxburghii* and *Cedrus deodara* forests can never be the climatic climax of the area and are the 'seral' communities. If the average gradient of the slope, the nature of the underlying rocks and physical character of the soil in *chir* forest be compared to those found existing in any adjoining forest climax, such a comparison should hardly show any marked difference and if these factors be considered for considering *chir* forests as edaphic climax then in the same way forests of *Quercus incana* and other forests must also be considered as edaphic climax. Osmaston (1922) argues that *chir* forests are kept in equilibrium by the action of periodic fires that are very common in the *chir* forests; it may be regarded that *chir* is comparitively immune to fire than any other species.

Since the fires in the *chir* forests during summers are caused by local villagers for the luxuriant growth of grass or by accidents they are likely to produce dry soils. It seems, therefore, that *Pinus roxburghii* forests are much influenced by biotic influences besides the nature of the underlying rocks and physical character of the soil. So, these forests may better be regarded as a *bio-edaphic climax* formation—a sub-climax, caused by the dryness of the soil and fires, so common in these forests, on account of the biotic interferences, showing a secondary succession to the climax community of oaks.

EFFECT ON THE VEGETATION

The natural vegetation in the Himalayas is greatly disturbed on account of factors arising from the socio-economic activity of the Himalayan people as outlined above. The monsoon and winter deciduous forests in the foot hills are extensively under the constant pressure of human influence. In the *Quercus incana* zone whenever a forest is extensively maltreated it gets reduced to a scrub stage and shows several degraded stages. Forests near the villages show this type of secondary scrub (dry and moist type) while the far away places and unaccessible areas show the climax type. *Pinus roxburghii* starts taking place after *Quercus incana* trees have been maltreated. At higher elevations *Quercus dilatata* and *Quercus semecarpifolia* communities have been greatly destroyed on the scarp slopes as a result of which *Pinus wallichiana* and *Picea smithiana* communities have developed. With intense biotic interference these finally degenerate into open pastures and thatches. The dip slopes generally are not much adversely effected, the sheep and goats feed on the dicot luxuriant vegetation. On scree deposits of these slopes the climax communities of oaks are greatly effected, since they are densely populated and on abandoned fields *Pinus wallichiana, Picea smithiana Pinus wallichiana* communities can be seen.

The flood plain deposits show pure communities of *Cedrus deodara* and *Pinus wallichiana* and many places cultivation, fire and grazing, promote erosion, landslides and gully formation. Pasturing on morainic deposits, having pure communities of *Abies* and *Picea* with or without *Quercus semecarpifolia* make regeneration of these species extremely difficult. Moreover biotic interferences at this height has brought *Pinus wallichiana* community and is responsible for its perpetuation.

SUGGESTIONS FOR THE IMPROVEMENT OF THE AREA

The following suggestions to develop certain industries based on the plants, with a view to reduce pressure on land, without disturbing the economic condition of the inhabitants have been made, based on the industrial survey report by Raturi (1947).

MAT AND BASKET INDUSTRY

Some of the plants are being used by the villagers for their local use for making mat and baskets. This industry can be developed on a large scale. The common plants that are employed for making baskets are species of *Rhus*, *Arundinaria*, *Salix* etc. Different types of 'ringals' growing in the oak forests may be exploited on a commercial basis for this industry,

RESIN GUM AND DYES

Forests of *Pinus roxburghii* occupy 728 Sq. km. in the district. Resin tapping provide employment for a large number of population. Small factories for the extraction of turpentine should be opened, that would greatly add to the economy and reduce the cost of oil also. Besides that, some plants *e.g. Acacia catechu*, *Butea monosperma*, *Nyctanthes arbor-tristis*, *etc.* can be exploited for the extraction of various gums and dyes.

FIBRE MAKING INDUSTRY

This industry has a very wide scope in the Himalayas. The villagers make fibre, for their local use, from the shoots of *Grewia oppositifolia*, *Cannabis sativa*, *Getardiana zeylanica* and *Agave americana* (leaves). Large areas in the district lying barren can be planted with *Agave* that can be used for fibre extraction, besides other plants, that can be commercially exploited.

WOOD ENGRAVING AND TURNING INDUSTRY

This industry has a wide scope of development in the area. The villagers make plates, cups and other wooden utensils for their local use. The same can be extended if proper facilities are provided to them and exported to the plains.

MULBERRY PLANTATION AND SERICULTURE

Trees of mulberry (*M. alba* and *M. serrata*) grow as scattered trees in different parts of the district. Artificially they are grown in Simlasu and other forest plantations. Silk worms were fed on the leaves of these trees by the erstwhile Maharaja but this could not go beyond the exprimental stage. There is a great possibility of sericulture succeeding in this area.

LAC CULTURE

A few thousand trees of *Schleichera trijuga* are present in district on which lac insects can be cultured. Leaves obtained from the lopping of these trees would provide food for the insects and thereafter healthy brood of lac can be obtained. Other plant species growing in the district can be tried for rearing lac insects on commercial basis.

FISHING

The natural species inhabiting the rivers are 'Masheer' 'rohi' and 'asivala'. Of these 'masheer' swims up in the valleys in hot weather and returns to the warmer parts in autumn. For the artificial plantation carried out during the erstwhile state, trouts have spread right upto Harsil and Dodital lake at the top. Kaldiyanai is heavily populated with these trouts. So, there is a good scope of this industry if more fish nurseries are opened.

A few other suggestions made to improve the economic conditions of the Himalayan people are :

1. Improved agricultural methods ;
2. Plantations of fruit trees and opening of Fruit Hybridization Centres ;
3. Land use planning ;
4. Pasture management ;
5. Exploitation of forest resources in a proper way for utilising timber and wood for other industrial uses,
6. Afforestation in the catchment areas and the spoiled habitats in the region of rivers Ganga and Yumuna,
7. Cultivation and exploitation of the medicinal plants ; and
8. Development of tourist centres.

ACKNOWLEDGEMENTS

I am deeply indebted to Dr. G. S. Puri, Director, Central Botanical Laboratory, Allahabad for his suggestions and guidance during these studies.

REFERENCES

Bahugnna, M. N. 1941. Working plan for the Tehri Forest Division 1939–40 1969–70. Dehra Dun.

Champion, H. G. 1919. Observations on some effects of fires on chir (*Pinus longifolia*) forests of the West Almora Division. *Indian For.* **45**: 353–364.

Champion, H. G., 1936. A preliminary Survey of the forest of India and Burma. *Indian For. Rec.* (N. S.) Silvic. I–1 : 1–126.

Gorrie, R. M., 1938. Pressure of population and Misuse of land in Punjab. *Scot. Geogr. Mag.* **54** : 284–295.

Gupta, R. K., 1959. Vegetation of Tehri Garhwal, North West Himalayas. *Proc. Indian Sci. Congress Assn.* (Abstr.)

Heske, Fr., 1930. Landwirtschaft und wald im W. Himalaya. *Forestschr.* d. *Landw.* Berlin. 4 **14/15** : 485–490 ; 517–521.

Heske, Fr., 1931. Probleme der walderhaltung im Himalaya. *Thar. Forstl. Jahrb.* **82** : 545–594.

Mohan, N. P. 1933. Ecology of *Pinus longifolia* in Kanga and Hoshiarpur Forest Division. *Indian For.* **59** : 812–826.

Mohan, N. P. and Puri, G. S., 1954. The Himalayan conifers Pt. III. The succession of forest communities in oak conifer forests of the Bashahr Himalayas. *Indian For. Rec.* **10** (2) : N. S. Silvic. 19–66.

Mohan, N. P. and Puri, G. S., 1955. Himalayan conifers—V. The succession of forest communities in Chir pine (*Pinus roxburghii*) forest of Punjab and Himachal Pradesh. *Indian For.* **82** (7) : 356–64.

Osmaston, A. E., 1920. Observations on some effects of fires and on lightening struck trees in the chir forest of the North Garhwal Division. *Indian For.* **46** : 125–131.

Osmaston, A. E. 1922. Notes on the forest communities of the Garhwal Himalaya. *J. of Eco.* **10** : 129–167.

Puri, G. S., 1950. The Distribution of conifers in the Kulu Himalayas with special relation to geology. *Indian Forest.* **76** : 144–153.

Raturi, P. D. 1947. Industrial Survey report of Tehri-Garhwal State. *Indian For.* **73** : 479–496.

CAPTIONS FOR THE PHOTOGRAPHS

Photo No. 1. A lopped up tree of *Bauhinia* in The Bhagirathi Ganga valley.

Photo No. 2. Grazing by the sheep of Jad and Bhutia traders in the coniferous forests of Bhagirathi valley.

Photo No. 3. Terrace cultivation on steep slopes in Alaknanda valley.

Photo No. 4. A degenerate community of Oak scrub showing the invasion of conifers from above.

STUDIES ON THE VEGETATION OF INDIAN ARID ZONE

VII—Foliar Analysis of Certain Desert Plants

By

B. M. SHARMA

Central Botanical Laboratory, Allahabad

INTRODUCTION

Thomas (1937) discussed the significance of foliar analysis as related to the relationship of nutrient uptake from the soil by plants. Lundegardh (1943) was of the opinion that analysis of leaves taken at the stage when the plant was fully grown, has advantages over soil analysis because it indicated precisely the availability of the nutrient salts in the soil. Thomas, Mack and Cotton (1943) laid an emphasis on the utility of leaf analysis as a quick method for getting necessary information regarding the nutritional status of the soil and the crop. McCollam (1944) held that it is in the leaf that the food material is accumulated and combined for redistribution through the whole plant. Goodall and Gregory (1947) emphasized that since leaves are the organs of active assimilation, their composition should be taken as the best possible basis in order to estimate the nutritional status of the whole plant. Walker (1955) found leaf analysis useful, indicating soil deficiency of potassium for normal growth of conifers. Wichstrem and Braun (1955) established through leaf analysis the primary deficiency of potassium in the soils of orchids in Medford area.

In India very little work has been done on leaf analysis and its application to fertilization of vegetation on other problems. Recently relationship between soil and plant calcium in *Shorea robusta* and teak and other Indian tree species has been established through leaf analysis (Puri, 1958). Ranjan (1954) also laid an emphasis on leaf analysis as an index of soil plant relationship. Bhatia (1956) carried out the foliar analysis of *Tectona grandis* in Madhya Pradesh. Bhatnagar (1957) determined the mineral constituents of foliage of Sal of different quality classes. A summary of information in this subject on Indian plants has been given by Puri (1960). With a view to present further data on foliar analysis of some common desert plants, the present study was undertaken.

MATERIAL AND METHOD

Leaf samples of the following six desert plants growing around the Churu town (Bikaner, Rajasthan) were collected during the months of August and September, 1960. *Prosopis spicigera* L., *Calligonum polygonoides* L., *Calotropis procera* R. Br., *Aerua tomentosa* Forsk., *Tephrosia purpurea* Pers. and *Cenchrus catharticus* L. Samples were collected from each plant growing at five different sites, the soil and other features of which are presented elsewhere. In all, thirty samples were collected. Except *Prosopis spicigera, Calligonum polygonoides* and *Calotropis procera,* the remaining plants were in flowering stage at the time of collection. Only fully developed and healthy leaves were gathered on each sampling date. The samples were dried, grounded into fine powder and transferred to bottles after the collection. Chemical analysis was done, based on the methods given by Piper (1944), for calcium, magnesium, phosphorus, sodium and potassium. In addition to these

ash and silica content were also determined. Nitrogen was determined by Kjeldahl method. All results have been expressed in percentage on air dry weight basis.

RESULTS AND DISCUSSION

The leaf contents of the plants studied are given in Table 1.

TABLE 1

Comparative Foliar Status of Desert Plants

Plant Species		Ca %	Mg %	P %	Na %	K %	N %	Ash %	Silica %
1. *Prosopis spicigera*	R.	2·03–2·88	0·24–0·69	0·05–0·21	0·30–0·43	2·19–3·04	0·63–2·17	7·56–10·74	0·24–0·73
	Av.	2·43	0·38	0·13	0·36	2·59	1·41	8·56	0·55
2. *Calligonum Polygonoides*	R.	2·22–2·82	0·82–1·10	0·05–0·09	0·31–0·39	1·58–3·17	0·98–4·06	7·55–11·65	0·50–1·12
	Av.	2·57	0·92	0·07	0·36	2·29	2·29	0·83	0·86
3. *Calotropis procera*	R.	2·17–2·62	0·71–0·82	0·07–0·24	0·84–1·06	2·78–3·42	0·26–0·73	13·27–15·37	1·12–2·50
	Av.	2·41	0·77	0·19	0·92	3·03	0·51	15·11	1·72
4. *Aerua tomentosa*	R.	2·55–4·30	0·54–0·89	0·03–0·10	0·93–1·08	2·96–5·85	0·26–0·39	11·00–16·80	1·25–3·25
	Av.	3·26	0·68	0·06	0·99	4·93	0·33	14·71	2·40
5. *Tephrosia purpurea*	R.	1·40–2·54	0·43–2·18	0·25–0·82	0·28–2·10	1·48–5·78	7·00–7·42	9·10–13·00	1·00–5·00
	Av.	2·00	1·03	0·49	0·87	3·38	7·25	9·96	2·19
6. *Cenchrus catharticus*	R.	1·00–2·40	0·45–4·15	0·14–0·72	1·87–4·05	2·93–4·06	1·33–6·93	11·2–17·00	1·00–4·00
	Av.	1·72	2·48	0·30	3·49	3·55	3·39	13·30	2·06

R. = Range. Av. = Average.

Prosopis spicigera Linn. an evergreen tree with pinnate leaves is dominant tree of the area reaching a maximum height of 40 ft. and grows on sandy plains, sand dunes in the Rajasthan desert.

The ash content of its leaves at different sites varies from 7·78% to 10·74% but the silica falls within a narrow range of 0·24% to 0·73%. Leaf calcium is found to range from 2·03% to 2·88% along with potassium in the range of 2·19% to 3·04%. Magnesium, phosphorus and sodium are comparatively poor in leaves of *Prosopis*. Nitrogen ranges from 0·63% to 2·17% (see table).

Calligonum polygonoides L., a small shrub with the usual height of 4 to 6 feet grows extensively on sand dunes and sandy plains of the area. It has minute leaves which fall off soon after their growth and for the major portion of the year this plant consists of green branches devoid of leaves. The branches were analysed. Stem, calcium and potassium are found to be high as in the former plant. Nitrogen ranges from 0·98% to 4·06%.

Calotropis procera R. Br., along with *Calligonum polygonoides* is another very common shrub on the sand dunes and sandy plains of the area. The ash content of its leaves ranges from 13·27% to 16·25% and silica from 1·12% to 2·5%. Leaf calcium and potassium are higher than magnesium and phosphorus. Sodium ranges from 0·81% to 1·06%. Nitrogen content of the leaves is poor,

Aerua tomentosa Forsk., is a herbaceous annual with its leaves covered with a wooly growth. The ash content is high varying from 11·00% to 16·8%. Silica ranges from 1·25% to 3 25%. Calcium and potassium cations are high. Magnesium varies from 0·54% to 0·89% while phosphorus and sodium fall within the range of 0·036% to 0·108% and from 0·93% to 1 08% respectively. Nitrogen content is poor.

Tephrosia purpurea Pers. The ash content of leaves ranges from 8·5% to 13·0% and silica from 1·00% to 5·00%. Leaf calcium and potassium ranges from 1·4% to 2·54% and 1·48% to 5·78% respectively. Nitrogen content of the leaves of this plant is quite high upto 7·4%.

Cenchrus catharticus L., a common grass of the area is rich in ash and silica. Calcium varies from 1·0% and 2·4% and potassium from 2·9% to 4·0%. This species is fairly rich in nitrogen which varies from 1·33% to 6·93%.

This study of foliar nutrient content of some of the desert plants suggest that :

1. *Aerua tomentasa* Forsk., is rich in calcium and potassium cations. It has also fairly high amount of ash and silica.

2. *Cenchrus catarthicus* L., possesses, high amount of sodium and magnesium cations with maximum silica and ash contents. It is, however, poor in calcium.

3. *Tephrosia purpurea* Pers., is in total nitrogen with fairly high K, and calcium, magnesium, potassium and ash.

4. *Prosopis spicigera* L., is poor in all the cations except nitrogen and calcium.

5. All the species are poor in phosphorus and most of them have very little sodium and magnesium.

APPLICATION OF THE DATA

Aerua tomentosa Fork., grows in abundance and is early to appear on sand dunes. It can be used for covering barren sandy habitats, poor in nitrogen, sodium and magnesium, the plant seems to flourish well on calcium-rich soils, and should be of particular interest and use in clothing of limestone sandy soils. Since the plant is rich in calcium and potassium it can probably be used as a green manure in soils in which these cations are deficient.

Cenchrus catharticus L., is a very common grass species of the area. As it is rich in sodium it may probably be utilised in reclaiming saline soils and may also be tried along with other plants capable of absorbing high amounts of Na. in afforestation of calcium poor soils.

Tephrosia purpurea Pers., which is a leguminous plant has high amounts of nitrogen and potassium. It may, therefore, prove to be a green manure of great value. Moreover, it is rich in other cations also and this adds to its utility as manure.

Prosopis spicigera L., *Calotropis procera* R. Br. and *Calligonum polygonoides* L., are in general poor in minerals. This makes the possibility of their use greatly in afforestation of the desert soils, which generally have a low mineral and nutritional status.

SUMMARY

Leaves of some common desert plants have been analysed. They show variation in the presence of various minerals. The information can be utilised in afforestation and other purposes. *Cenchrus catharticus* L., has been suggested for reclamation of saline soils while *Tephrosia purpurea* Pers. and *Aerua tomentosa* Forsk., as green manure.

LITERATURE CITED

Bhatia, K. K. 1956. Contribution to the ecology of Teak in Madhya Pradesh, *J. I. B. S.* Vol. **35**, pp. 357-364.

Bhatnager, H. P. 1957. Mineral constituents of foliage of *Sal* of different quality classes. *Ind. For.* **83**.

Goodall, D. W. and Gregory, F. G. 1947. Chemical composition of plants as an index of their nutritional status. *Imperial Agricultural Bureaux, London.*

Lundegardh, H. 1943. Leaf analysis as a guide to soil fertility. *Nature*, **151** : 310–311.

McCollam, 1944. Leaf analysis – a guide to better crops. *Betters crops with Plant Food*, **28** (10), 11–14, 42.

Puri, G. S. 1954*a*. The foliar constituents in some tree species of *Shorea robusta* forests of the Siwaliks, U. P. *Ind. For.* **80** (11) : 700–706

——— 1954*b*. Seasonal variations in foliar composition of some Indian forest trees. *J. I. B. S.*, **33** : 382–393.

——— 1954*c*. Leaf analysis studies of Indian vegetation. *The English Book Depot, Poona.*

——— 1954*d*. Foliar ash contents in some *Shorea robusta* trees of different quality classes and its relation with soil calcium in some forests of India. *Ind. For.* **81** : 98–102.

——— 1958. Foliar ash and *Sal* distribution in relation to soil. *Sci. and Cult.* vol. 24, 41–43.

——— 1959. Nitrogen content of leaves of some exotic and indigenous forest trees species planted at New Forest. *Ind. For.* vol. 85, No. **7** : 426–430.

——— 1960. Forest Ecology, vol. II. *Oxford Book Co., New Delhi.*

Ranjan, S. 1954. Presedential address at 24th Annual Meeting. *Nat. Acad. Sci. India* 1–10.

Thomas, Walter, 1937. Foliar diagnosis, principles and practice. *Plant Physiol.*, **12** : 571–599.

Thomas Walter, Mack, W. N. and Cotton, R. H. 1943. Leaf analysis as a mean of determining the fertilizer requirement of crops. *Amer. Fertilizer.* **98** : 5–7.

Walker, L. C. 1955. Foliar analysis as a method of indicating potassium deficient soils for reforestation. *Soil Sci. Soc. Amer. Proc*, **19** : 233–236.

Wichstrom, G. A. and Braun, C. H. 1955. Leaf analysis reveals potash need in Southern Aregon. *Better Crops with Plant Food*, **39** : 17–20.

GENERAL FEATURES AND FLORISTIC COMPOSITION OF TROPICAL EVERGREEN FORESTS OF INDIA

By

H. P. BHATNAGAR

Forest Researeh Institute, Dehradun

Tropical rain forests are the climax formation in humid tropics. It is considered that the tropical rain forests have been the center of evolutionary activity from which the rest of the World's flora has evolved These forests which cover about more than half of the Worlds forest area have not been subjected to detialed study and data on the community life of plants, floristic compositiom, succession, regeneration status, the effect of various biotic factors etc. from these forests is very meager. These forests have become economically very valuable during recent years with the development of timber industries and it is therefore, necessay to obtain detailed information of these forest types.

Distribution :

These forests are situated in warm tropics with humid climate. In India the tropical evergreen forests are distributed far apart in different regions of the country, the forests of each region having its own characteristics. In the north-east they occur in the high rainfall belt of Assam and N. E. F. A. and in the southwest along the western coast. Champion (1936) has classified tropical evergreen forests of India into two broad classes, *viz.* (*i*) Southern Tropical evergreen forests (Kerala, Mysore, Madras, and Andaman islands), (*ii*) Northern Tropical evergreen forests (Assam, North East Frontier Agency and West Bengal).

In Mysore state tropical evergreen forests mostly occupy the slopes of the Western Ghats facing Arabian sea.

They cover a strip approximately 250 miles long and 10 to 15 miles wide an approximate area of about 3,000 square miles.

In Kerala exact delimitation of wet evergreen forests in rather difficult because very often the patches or groups of moist deciduous forests are interspersed. At higher elevations the wet evergreens merge into so called "Shola". In this state they are found to occur throughout the length of Kerala from Kasargode to Neyyathukara wherever they are not destroyed by fire and shifting cultivation.

In Madras the extent of the evergreen forests is very small and cover only about 150 square miles in scattered patches and in small isolated areas. These forests are confined to the eastern slopes of the western ghats and are situated in Coimbatore, Tirunalveli, Kanyakumari, Nilgiris and Madurai districts.

The state of Bombay is practically devoid of tropical evergreen forests. The sub-tropical evergreen forests, however occur in the following localities, Sawantwadi sub-division, Kolhapur, Satara, Poona and Kolaba divisions with a total area of 159610·38 acres.

The northern tropical evergreen forests include Sikkim, slopes of the Eastern sub-Himalayan range and northern Assam. The evergreen forests of Assam occupy a major portion of Lakhimpur, Sibsagar and Cachar districts and almost a contineous narrow belt all along the foot of the Himalaya stretching from the extreme north-east corner to the west.

The area under evergreen forests in Andaman islands include the upper slopes of the hills and micaceous sandstone sub-strata in south and middle Andamans.

Topography :

In general these forests occupy alomst flat level land, broken hills which are intersected by streams and swamps (Northern Tropical Evergreen Forests) and hilly undulating and precipitous slopes intersected by numerous narrow ridges and valleys (Southern Tropical Evergreen Forests).

In the Western ghats region the country is mountaneous, this covers most of Kerala and parts of Mysore and Madras States. The drianage in general is west ward towards the Arabian sea. There are numerous streams many of them are perennial. In Kerala State there are many small or large leaps of water locally known as 'Abdulu or Abbi" all along the ghats. The forests in this region occur between 3000 ft. to about 6000 ft. The average elevation is about 500 ft. to about 2500 ft. in Madras, and are confined upto 4500 ft. in Kerala.

In the northern region the forests generally occur on almost flat level land as also on broken hills with numerous streams and swamps. The altitude varies from 95 meters to about 498 meters.

Geology, rock and soil :

The nature of rock and soil varies considerably from place to place. The western ghats consists generally of old crystalline rocks. The main rock formation is granitic gneisses interspersed by bands of horn-blende schist with or without garnet. Lateritic formations are of wide spread occurrence and are found largely in a belt at varying depths on the hills. The soil on the lower slopes and valleys is considerably deeper and finer in texture while on higher slopes, ridges and tops soil is shallow. Various soil groups occur in this region *viz.* laterites, red loam, medium black soil, hill soils, red gravelly soils, alluvial soils including coastal alluvium and mixed red and black soils. The soils are generally rich in humus (about 10–40% organic matter). In Andaman islands the predominant formation is sedimentaries which consists of sand stones and conglomerates, while on hills and ridges serpentine series of igneous rocks, which consists of jaspar, limestone and quartzites, is, common. The sedimentry rocks gives rise to a coarse and infertile sandy loam soil which is excessively permeable. The serpentine series produce deep and fertile dark red loam which is relatively less permeable. The areas near streams and tidal flats consists of alluvium.

In Assam sedimentry beds are more common consists of alluvium which are varied in character. Tertiary beds consists of sandstone, conglomerates and shales, while cretaceous beds are mainly sandstones, conglomerates and shales. Igneous and metamorphic rocks also occur but are not common. Older metamorphic rocks consists of gneisses, schists and quartzites. Granite and dolerite are found as intrusions into the metamorphic rock. In the hilly region the rocks are generally of tertiary age composed chiefly of gneiss which is made up of magnetite and very little of hornblende and mica.

Varying type of soil occur in Assam region *viz.* alluvial soils, red loam, laterite soil (old ailuvium high and low level) and hill soils. In Assam the tract for the most part consists of alluvial deposits. The alluvial deposits can be devided in high and low level alluvium. The high level alluvium consists of rather stiff, reddish, somewhat sandy clay with occasional beds of fairly pure clay and frequently patches of rather coarse sand. The soil here on the whole is generally loamy of considerable depth. The low level alluvium consists of shallow surface layer of silty loam and of a grey colour with sub-soil of coarse sand sometimes mixed with pebbels and boulders. The old alluvium on the

hills are more acidic than the new alluvial soils adjoining the river banks. Very frequently the new alluvial soils are neutral or even alkaline in reaction.

Climate :

The characteristic feature of the climate of tropical evergreen forests are high rainfall, moderate temperature for a greater part of the year with little or no winter, and high atmospheric humidity. Considering the whole tract where the tropical evergreen forests occur the morning atmospheric humidity is seldom less than 80 per cent and the average annual rainfall is above 2000 m.m., the mean annual temperatnre lies between 10 C–21°C. In Southern tropical forests it is usually 20°C while in the Northern tropical forests it is usually about 13°C, local variations are always metwith.

Temperature and Humidity :

In the region of southern tropical evergreen forests the mean annual temperature flatuates between 70°F to 90°F mostly depending on elevation. The warmest months are February to May, April and May are the hottest. Humidity does not fall below 80 percent but in rainy season it reaches saturation point, winter does not occur, December and January are the coolest months. In Mysore temperature is relatively constant and low as compared with that of the low lands of South or North Kanara, but never so low as to make frost possible.

In Assam winter months are cool and comparatively dry. The coldest months are December and January and the hottest are June, July and August. Temperature varies from 7°C to 38°C in summer.

Rainfall :

The Western Ghat region is a tropical montane evergreen region and is influenced by the south-west monsoon. Rainfall is abundant in this region. Rainy season starts in June aud remains uptill August. The north-east retreating monsoon bring light showers during October and November. Rainfall varies from state to state *viz.* in Kerala it varies from 120" to 150" (but in places like Anamudi it is 380"), while in Mysore it varies from 2000 m.m. to 5000 m.m. The driest months are from January to May. At places drought in summer is fairly severe and the hygrophylous vegetation shrival and even some evergreen trees shed a good portion of their foliage or even whole of their leaves. The northern tropical evergreen forests lie in the tract where the average annual rainfall ranges from 2130 m.m. to 3790 m.m. The number of rainy days varies from 128 to 175 in a year.

Floristic composition :

Utmost luxuriance of vegetation is a coaracteristic feature of evergreen tropical forest formation. The emergent layer is sparse but the contineous top canopy is dense and consists mainly of lofty trees reaching a height of about 45 meters or more, often with high plank buttresses. The middle and the lower storey consists of evergreen trees struggling hard for light and than the layer, consists of dense shrubby evergreen vegetation. The ground cover is very sparse and grasses are very few or absent. The species are very abundant but gregariousness is strickingly absent. There is an abundance of thick stemmed climbers, climbing palms and epiphytes (Aroides, Ferns, Orchids, Liverworts etc.). The undergrowth is often a tangle of canes creeping bamboos and palms. But the floristic composition varies greatly from place to place and state to state.

The forests of Western Ghats exhibit tropical characteristics both in their composition and general ecology. There is not a single species of the temperate type, and no gymnosperm except the gignatic climber *Gnetum scandens*. There are generally considerable peculiarites of form. The valleys and slopes are the home of evergreen forests of magnificient type. The larger trees especially species of *Elaeocarpus, Alstonia, Ficus, Myristica, Artocarpus* and *Lophopetalum* and many others have plank buttresses. The main characteristic of the forests remain almost same although the vegetation varies widely from north to south.

The common species of these forests occurring in Mysore state are as follows, common species of the top canopy are *Acrocarpus fraxinifolius, Antiaris toxicaria, Artocarpus hirsuta, A. heterophyllus, Bischofia javanica, Canarium strictum, Cedrela toona, Dipterocarpus indicus, Kingiodendron pinnatum, Mesua ferrea, Euphoria longana, Palaquium ellipticum, Trewia nudiflora, Vateria indica.* Common species of the middle storey are, *Albizzia julibrissin, Callophyllum elatum, Carallia brachiata, Donella roxburghii, Cinnamomum zeylanicum, Dillenia pentagyna, Diospyros ebenum, D. bilagirica, Drypetes elata, Elaeocarpus tuberculatus, Eugenias* spp., *Fagara budrunga, Hydnocarpus laurifolia, Knema attenuata, Vitex altissima, Polyalthia fragrans, Xylocarpa, Myristica magnifeca, M. malabnrica, M. laurifolia.* Common species of under storey are, *Allophylus phoebe, Aporosa lindleyana, Bauhinia recemosa, Lansium anamalayanum, Feronia limonia, Memecylon angustifolium, Xanthophyllum flavescens.* Undergrowth consists chiefly of *Arenga wightii, Calamus pseudotenuis, C. rheedei, C. thwaitesii, Callicarpa lanata, Clerodendrum infortunatum, Clinogyne virgata, Helicteres isora, Laportea crenulata, Macaranga peltata, Ochlandra rheedii, O. travancorica, Pandanus tectorius, Strobilanthus barbatus, Webra corymbosa.*

Tropical moist evergreen formation of Kerala state can be broadly distinguished into two main types *viz.* (*i*) Western tropical evergreen formation this comprises the majority of evergreen forests of the state. (*ii*) High range shola evergreens, they occur on sheltered valleys above 4,500 ft. These two types are different in general appearance firstly the canopy differentiation is not possible the trees are not very high and are branching in the latter type while three tires can be easily distinguished in the former in which trees are tall with clean cylindrical bole. One more type can be distinguished which is not truely evergreen is West Coast Tropical-semi-evergreen.

In the westetn tropical evergreen formation the following associations can be distinguished : *Cullenia–Plaquium, Plaquium–Mesua, Poeciloneuron–Plaquium, Mesua calophyllum, Vateria–Cullenia, Mesua–Cullenia, Reed–Callophyllum* and *Reed–Poeciloneuron.*

The most conspicuous species of western tropical evergreen forests are as follows. Top canopy consists chiefly of *Acrocarpus fraxinifolins, Ailanthus malabarica, Anacolosa densiflora, Antiaris toxicaria, Artocarpus hirsuta, Bischofia javanica, Calophyllum elatum, Carallia brachiata, Cedrela toona, Cullenia excelsa, Dipterocarpus bourdillonii, D. indicus, Diospyros assimilis, Dysoxylum malabaricum, Elaeocarpus tuberculatus, Eugenia arnottiana, E. chavaran, Filicium decipiens, Hopea parviflora, H. racophloea, Lophopetalum wightianum, Machilus macrantha, Mangifera indica, Mesua ferrea, Knema attenuato, Myristastica malabarica, Palaquium ellipticum, Polyalthia fragrans, Pterospermum reticulatum, P. rubigonosum, Sterculia alata, Syzygium cumini, Tetramels nudiflora* and *Vaterta indica.*

The commonest species of the middle storey are, *Acronychia laurifolia, Actinodaphne hookeri, Amoora rohituka, Aporosal indleyana, Baccaurea courtallensis, Bocagea dalzelli, Canarium strictum, Cinnamomum zeylanicum, Diospyros microphylla, Elaeocarpus serratus, Evodia roxburghiana, Fagara budranga, Ficus* spp., *Garcinia morella, Holigarna arnottiana,*

Hopea glabra, Hydnocarpus laurifolia, Litsaea spp., *Macaranga roxburghii, Mallotus philippensis, Memecylon edule, Mimusops elengi, Myristica beddomei, Euphoria longana, Pithecolobium bigeminum, Pygeum wightianum, Vernonia travancorica* and *Xanthophyllum flavescens.*

The common species of the lower canopy are *Agrostistachys indica, A. longifolia, Eugenia munroruii, E. laeta, Euonymus angulatus, Paramignya armata, Sauropus albicans, Apama siliquosa, Callicarpa lanata, Clerodendrum infortunatum, Croton scabiosus, Laportea crenulata, Laea sambucina, Lepisanthes deficiens, Linociera malabarica, Macaranga roxburghii, Olea dioica, Orophea uniflora, Pavelta zeylanica, Paramignya armata, Sarcococea brevifolia, Saprosma fragrans, Sauropus albicans, Strobilanthus* spp., *Turpinia malabarica* and *Webera* spp.

The ground flora consists of *cardamomum* spp., *Curcuma* sp., *Strobilanthus, Selaginella,* Species of *Calamus, Pandanus, Pinanga, Reeds, Derris, Smilax macrophylla* are the common climbers. The common species of the high range shola evergreens are the following, *Actinodaphne hookeri, Alseodaphne semecarpifolia, Bauhinia racemosa, Clausena* spp., *Cinnamomum sulphuratum, C. wightii, C. zeylanicum, Daphiphyllum glaucescene, Eugenia arnottiana, E. gardneri, Eurya japonica, Euonymus* spp.. *Ficus* spp. *Humboldtia* sp., *Ixora* sp., *Ilex denticulata, Litsaea* spp., *Meliosma wightii, Michelia* sp., *Nothopegia dalzelli, Photinia notoniana* and *Rhododendron arboreum.* Undergrowth consists chiefly of *Arundinaria wightiana, Teinostachyum beddomei, Ardisia* sp., *Ligustrum* sp., *Rhamnus* sp., *Strobilanth* sp., *Viburnum* sp. *Berberis nepalensis, Dodnea viscosa, Eupatorium* ps., *Gaultheria fragreantissima* and *Hypericum, Rosa Clematis* sp., *Rub us* sp., and *Elaeagnus latifolia* are the common climbers.

In Madras state the rainfall and temperature varies within short distances and due to this variation the floristic composition also varies from place to place. In Tirunelveli, Ramanathapuram and Kanyakumari districts the tropical wet evergreen forests are found from about 2,000 ft. and above upto 4,000 ft. almost touching the crest of the mountains. In these forests the chief associations met with are *Mesua-Plaquium, Gluta-Plaquium* and *Plaquium-Mangifera.* However, the first two associations are not very distinct. These associations are not very marked in Kanyakumari district. Along the higher slopes and even very near to sumit on various mountain ranges extensive areas are covered with reeds *Ochlandra brandisii* and *O. travancorica* form impenetrable thickets. *Bentinckia condapanna* thrives on steepest slopes and is having gregarious growth in reed areas.

In Coimbatore district the forests occur from 2,000 to 5,000 ft. on the Anamallai hills *Hopea-Mesua, Mesua, Plaquium* and *Poeciloneuron-Cullenia* are the chief associations metwith. In higher rainfall areas of about 200 in. *Poeciloneuron-Cullenia* association is very common while where the rainfall is about 120 in. *Mesua-Plaquium* association is quite common and in areas where rainfall is between 70-100 in. *Hopea mesua* association is common. In Madurai district due to less rainfall the evergreen forests are not as typical as those in Coimbatore district.

The most common species of the Tropical moist evergreen forests of Madras state are as follows, *Aglaia roxburghiana, Aglaia caurtallensis, A. barberii, Adenochlaena indica, Alstonia scholaris, Artocarpus integrifolia, A. lakoocha, Acrocarpus fraxinifolius, Balanocarpus utilis, Bischofia javanica, Canarium strictum, Chickrassia tabularis, Cedrela toona, Cullenia excelsa, Calophyllum elatum, C. tomentosum, Cinnamomum gracile, Canthium dicoccum, Casearia esculenta, Dalbergia latifolia, Diospyros microphylla, Dysoxylum malaboricum, Drypes macrophylla, Elaeocarpus tuberculatus, E. serratus, E. oblongus, Elaeodendron glaucum, Eugenia* spp., *Gluta travancorica, Heritiera papilio, Hydnocarpus wightiana,*

Hardwickia pinnata, Hopea parviflora, Lagerstroemia lanceolata, Litsaea sp., *Mangifera indica, Mesua ferrea, Myristica laurifolia, Mallotus philippensis, Michelia champaca, Mimusops elengi, Nephelium longana, Palaquium ellipticum, Pterospermum rubigonosum, P. glabrescens, Poeciloneuron indicum, Podocarpus latifolia, Stereospermum chelonoides S. heyneanum, Sapindus emarginatus, Salmalia malabarica, Schleichera oleosa, Vateria indica, Vitex altissima.*

Undergrowth consists chiefly of *Calamus pseudotenuis, Curcuma pseudomontana, Laportea crenulata, Oplismenus burmannii,* gregarious patches of *Ochlandra travancorica, O. brandisii, Pandanus* sp., *Pteridium autilinum, Strobilanthes* sp., *Solanum* sp., *Card amomum sp.* reeds etc., common climbers are *Calicopteris floribunda, Elaeagnus kologa, Entada scandens, Abelia excelsa* and *Polygonum* sp. Common ferns and palms are *Bentinckia condapanna, Pinanga dicksonii, Caryota urens.*

In Assam the evergreen formation can be distinguished on the basis of elevation into two main classes, (*i*) sub-montane evergreen formation which is confined to Khasi and Jaintia Hills and the Naga Hills at about 5000, ft. represented by *Oak-Rhododendron* formation and an almost pure oak formation in North Cachar hills at about 2000 ft. The second broad class is Tropical evergreen forests which covers the major part of the Assam evergreen forests. In this type the following two main evergreen formations can be recognised, *Mesua-Dipterocarp* and *Kayea assamica.* In *Mesua-Dipterocarp* formation two sub-types can be easily recognised, one is Cachar *Mesua-Dipterocarp-Plaquium* formation. "The characteristic species of this type are *Dipterocarpus turbinatus, Mesua ferrea, Kayea floribunda, Palaquium polyanthum, Diospyros topasia, Heritiera acuminata, Nephelium longana, Cynometra polyandra, Eugenia* spp., *Sapium baccatum, Canarium* spp., *Vatica lanceaefolia, Taraktogenous kurzii, Podocarpus neriifolia, Alseodophne owdeii, Amoora* spp., *Aquilaria agallocha, Calophyllum polyauthum, Dysoxylum binectariferum, D. reticulatum, Diospyros lanceaefolia, Magnolia* sp., *Mangifera indica, Sterculia elata, Terminalia chebula.*

The second sub-type is in upper Assam *Mesua-Dipterocarp* forests. In this sub-type two types are met with one consisting chiefly of *Shorea assamica* and *Mesua ferrea* and the other cosisting chiefly of *Dipterocarpus macrocarpus* and *Mesua ferrea* but without or very little *Shorea assamica.* The commonest species of the top canopy are *Dipterocarpus macrocarpus, Amoora wallichii, Artocarpus chaplasha, Chickrassia tabularis, Cinnamomum cecicodaphne, C. glanduliferum, Endospermum bhinense, Dysoxylum procerum, Elaeocarpus rugosus, Engelhardtia spicata Manglietio insignis, Magnolia gustavi, Michelia oblonga, M. baillonii, Shorea assamica Panchylaruax pleiocarpa, Polyalthia simiarum Syzygium cumini.*

Middle and the lower stories consist chiefly of *Mesua ferrea, Vatica lanceafolia, Ammoora chittagonga, Aphanamixis polystachyo, Canarium bengalense, Michelia manii, Cedrela toona, Kurrima robusta, Mallotus albus, Magnolia griffithi, Michelia montana, Pterospermum lanceaefolium Syzygium cumini, Talauma hodgsoni.*

The undergrowth consists chiefly of *Alpinia allughas, Amblinanthus multiflora, Dracaena angustifolia, Eupatorium odoratum Ixora subsessilis, Laportea crenulata, Melastoma malabaricum, Morinda angustifolia, Osbeckia nepalensis, Leea* spp., *Phlogacanthus thyrisflorus, Pinanga gracilia, Phrynium capitatum, Saprosma ternatum.* Commonly occurring canes are *Calamus errectus, C. flagellum C. floribundus, C. latifolius* and *C. leptospadix* and common bamboos are *Dendrocalamus hamiltonii, Pseudostachyum polymorphum* and *Teinostachyum dullooa.* Common climbers are *Aspidocarya uvifera, Clematis acuminata, Entada phaseoloides, Fissistigma bicolor, Tetrastigma camphylocarpa* and *Tetrastigma obovatum.* The common epiphytic flora is *Aroides* spp., *Luisia* spp., *Bulbophyllum* spp., *Helixanthera* spp., *Viscum* spp.

The evergreen *Kayea assamica* formation occurs in the extreme east on the north bank of river Bhramaputra. In this type *Mesua ferrea* gives way to *Kayea assamica*. *Dipterocarpus macrocarpus* is almost absent. *Kayea assamica* forms about 70% of the crop. Other common species are *Dysoxylum* spp., *Pterospermum lanceaefolium, Canarium* spp., *Echinocarpus assamicus, Mesua forrea, Terminalia chebula, Amoora wallichii, Pterospermum acerifolium, Zanthoxylum budranga, Terminalia belerica, Eugenia* sp., *Dysoxylum hamiltonii, Artocarpus chaplasha, Altingia excelsa, Dipterocarpus macrocarpus, Cinnamomum ceciccodaphne, Mansonia, dipikai, Michelia montana, M. champaca, Premna bengalensis.*

SUMMARY

Evergreen forests are characterised by luxuriance of vegetation which may differentiate itself into three or more tiers. The emergent layer is sparse but the continuous top canopy is dense and consists mainly of lofty trees reaching a height of about 45 meters or more, often with high plank buttresses. The middle storey consists of evergreen trees, struggling hard for light and the lowest layer consists of dense shrubby evergreen vegetation. The ground cover is very sparse and grasses are very few or absent. The species are very numerous but gregariousness is strickingly absent. There is an abundance of thick stemmed climbers, climbing palms and epiphytes (Aroider, Ferns, Orchids, Selaginella and Lichens). The undergrowth is often a tangel of canes, creeping bamboos and palms., The most common species of evergreen forests of India are named in the paper.

ACKNOWLEDGEMENTS

My grateful thanks to Sri. S. K. Seth and Sri. M. A. W. Khan for helpful suggestions.

REFERENCE

Champion, H. G. 1936. A preliminary survey of the forest types of Idian and Burma.

NEED FOR STUDIES IN POPULATION DIFFERENTIATION IN INDIAN PLANTS

By

P. S. RAMAKRISHNAN

*Department of Botany, Meerut College, Meerut**

Variation in plant species may be of two types—that which is controlled by the environment (modifications) and that which is governed by heredity (genetic differences). The former are termed as ecads and the latter as ecotypes.

The concept of ecotype is very well known to the modern ecologist through many studies beginning with the works of Turesson (1922 a, b, 1923, 1925, 1930), who brought plants from many habitats and grew them under uniform conditions in a garden at Akarp, in Southern Sweden. By extensive cultures and statistical analysis of populations and genetic tests, he found that a great majority of variations within a species were due to hereditary characters, each remaining distinct when grown in a neutral substratum. He visualises the climate as a selective agent which controls the growth forms in a partcular habitat. This selective influence over a long period of time and a range of habitat conditions results in the differentiation of ecotypes of a species.

The outstanding studies of Clausen *et al.* (1940, 1948) in Amercia has shown, for example, the existence of chains of climatic races in a number of perennial species ranging from the sea level to above the timberline in California. Clausen *et al.* (1948) have recognised at least 11 diverse climatic races along a 200 mile transect across Central California, in *Achillea.* They have shown that species that have the widest distribution have many ecotypes and those with a narrow distribution have fewer races.

Recognition of the existence of edaphic and biotic ecotypes implies a level of ecotypic differentiation besides the climatic and geographic levels. Thus, for example, Kruckeberg (1951) has differentiated two edaphic ecotypes in *Achillea borealis* Californica (Clausen *et al*, 1948) in relation to serpentine and non-serpentine soils. Stapledon (1928) has recognised a number of biotic ecotypes in Cocksfoot grass (*Dactylis glomerata*) in relation to the intensity of grazing.

Ecotypic differentiation in plants has received very meagre attention of ecologists in India, so far. Some work has already been done in this country on edaphic ecotypes. Misra and Siva Rao (1948), for example, have recognised two ecotypes in *Lindenbergia polyantha* Royle. with regards to their capacity to grow in calcareous and non-calcareous soils and also to absorb calcium from such soils. Two ecotypes—an erect type and a prostrate type have been distinguished in *Euphorbia hirta* Linn. in relation to moisture conditions of the substratum, at Varanasi (Ramakrishnan, 1960a). A tall form growing in very moist to water-logged soils such as along the margin of pools and a short form growing in comparatively drier localities have been recognised in *Echinochloa colonum* Link. (Ramakrishnan, 1960b.) Ramakrishnan (1960c) has also recognised two ecotypes—

*Present Address : Dept., of Botany, Punjab University, Chandigarh—3.

a long panicled form and a short panicled form, in *Setaria glauca* Beauv. with regards to the soil moisture conditions, texture and topography of the substratum. In *Euphorbia thymifolia* Linn., two ecotypes, a red form and a green form, the former a facultative calcicole and the latter an obligate calcifuge, have been delimited with respect to calcium nutrition and their capacity to thrive in calcareous and non-calcareous soils. These two ecotypes have been found to be freely interbreeding in nature and a duplicate factor has been found to control the inheritance of anthocyanin pigmentation (Ramakrishnan, 1960 d, 1961).

The vegetational types in India range from the desert vegetation of Rajasthan to the wet evergreen forest of the Eastern Himalayas and the Western Ghats in relation to rainfall, tropical, temperate and alpine vegetation in relation to temperature and altitude. Soil types also show a wide range of variation. Under the residual soil types we have the red soils, laterite and lateritic soils and black soils or 'regur'. Besides, we have alluvial soils of different types, mountain soils, arid and desert soils, saline and alkaline soils, peat soils, etc. Such a wide range in climate, soil and vegetational types offers a vast scope for investigations on climatic and edaphic races. Basides, the influence of domesticated animals on the vegetation, in a predominantly agricultural country like India, and the resultant differentiation of biotic ecotypes akin to that in *Dactylis glomerata* L. (Stapledon, 1928) cannot be overlooked.

Misra (1959) has pleaded for the establishment of a chain of field stations where plants can be grown at different altitudes and on regional soils under different climatic conditions. This will facilitate to a great extent this type of study which if pursued further in this country will throw fresh light on the pattern of ecotypic differentiation of plants in relation to climate, soil and biotic factors.

REFERENCES

Clausen, J. *et al.* 1940. *Experimental Studies on the Nature of Species.* 1. *Effect of Varied Environments on Western North American Plants.* Carnegie. Inst. Wash. Pub., **520** : 1–452.

Clausen, J. *et al.* 1948. *Experimental Studies on the Nature of Species.* III. *Enviornmental Responses of Climatic Races of Achillea. Ibid.*, **581** : 1–129.

Kruckeberg, A. R. 1951. Intraspecific variability in the response of certain native plant species to serpentine Soil. *Amer J. Bot.* **38** : 208–419.

Misra, R. 1959. Environment, Adaptation and Plant Distribution—Presidential Address. Botany Section, *Proc. Indian Sci. Cong.*, Delhi Session.

——— and Siva Rao, B. S. 1948. A study in the autecology of *Lindenbergia polyantha* Royle. *J. Indian Bot. Soc*, **27** : 186–199.

Ramakrishnan, P. S. 1960*a*. Studies in the autecology of *Euphorbia hirta* Linn. *J. Indian bot. Soc.* **39** : 455–473.

——— 1960*b*. Ecology of *Echinochloa colonum* Link. *Proc. Ind. Acad. Sci.*, **52B** : 73–90.

——— 1960*c*. Ecology of *Setaria glauca* Beauv. (Abstract). *Proc. Ind. Sci. Cong.* Pt. III, 410.

——— 1960*d*. Distribution of *Euphorbia themifolia* Linn. in relation to soil calcium. *Mem. Indian bot. Soc.* **3** (in press).

Ramakrishnan, P. S. 1961. Calcicole and calcifuge problem in *Euphorbia thymifolia* Linn. *J. Indian bot. Soc.*, **40** : (in press).

Turesson, G. 1922*a*. The species and variety as ecological units. *Hereditas*, **3** : 100–113.

——— 1922*b*. The genotypical response of the plant species to the habitat. *Ibid.*, **3** : 211–350.

——— 1923. Scope and import of genecology. *Ibid.*, **4** : 171–176.

——— 1925. The plant species in relation to habitat and climate—Contributions to the knowledge of genecological units. *Ibid.*, **6** : 147–236.

——— 1930. The selective effect of climate upon the plant species. *Ibid.*, **4** : 99–152.

Stapledon, R. G. 1928. Cocksfoot grass (*Dactylis glomerata* L.) ecotypes in relations to the biotic factor. *J. Ecol.*, **16** : 71–104.

STUDIES ON MANGROVES

By

S. S. SIDHU

Central Botanical Laboratory, Allahabad

INTRODUCTION

The study of mangrove habitat is important on account of its economic possibilities in the field of Soil conservation and flood control, forestry and pure botany. This therefore needs a special attention from scientific as well as social angles. India has a fairly vast coastal line and study of its mangrove resources can provide extremely useful data in protecting its coastal areas. The mangroves are the so called 'Himalayan guards of coast' and 'Builders and Guardians of Coastal land'. The need of such studies has been stressed by various authors (Roxburgh 1796, Puri 1960, Patil 1961, Sidhu 1961, Bharucha and Navalkar 1942). Nevertheless, the present studies were undertaken at the suggestion of Dr. G. S. Puri.

Mangrove constitute a type of habitat forming forests in estuaries, salty marshes and muddy coasts between high tide and low tide level. They occur in areas with 65–500 cms. average annual rainfall and with average annual temperature 27–32°C, on alluvial deposits, geologically of the recent or Pleistocene period (Croizat 1952) and the habitat is as old as the origin of early land flora. Schimper (1903) in his book 'Plant Geography' has briefly discussed the distribution and characteristics of mangroves of the world. Good (1952) enumerated 30 mangrove species, India ranking next to the Malayan Islands as regarding the concentration species. Including the alophytic herbs and sand dune species the group comprises of about 70 species belonging to about 20 natural orders. The species belonging to the families Rhizophoraceae, Verbenaceae, Sterculiaceae, Euphorbiaceae, Combretaceae and Palmae are comparatively of much more importance as far as their productive and protective role is concerned.

Geographical distribution of mangroves :

Based on the geographical distribution the mangroves are divisible into two main groups (Schimper, 1903).

1. The Western mangroves and
2. The eastern mangroves.

Western mangroves : The species are only 4 in number and are restricted to the coasts of America and West coast of Africa.

Species		Distribution
Rhizophora mangle Linn.	...	East and West coast of America
Laguncularia racemosa	...	Both the coasts of America and West coast of Africa
Avicennia nitida	...	do
Avicennia tomentosa. Jacq.	...	Restricted to the coasts of America.

Eastern mangroves : The species extend from east coast of Africa—India—S. E. Asia and Pacific Islands.

Among the eastern mangroves, some species have continuous distribution from west African coast—Australia, others are distributed from Africa to S. E. Asia only and certain others have restricted distribution to India and Malaya. Only two species are restricted to India only *viz.*, L. sp. reported from E. Godavari and *Avicennia marina* Vierh.

The following table gives an overall picture of the distribution of different species of the eastern mangroves.

Species		Distribution
Rhizophora mucronata Lam.	...	Africa–Australia
R. conjugata Linn.	...	Africa–Pacific Islands
Ceriops roxburghiana Arn.	...	do
C. candolleana Arn.	...	do
Bruguiera conjugata Merr.	...	do
Lumnitzera racemosa Willd.	...	Africa (east coast only) Australia
Sonneratia alba Smith	...	do
Xylocarpus obovatus A. Juss. (—*Carapa moluccensis* Lamk.)	...	do
Carapa obovatus Bl.	...	Africa–Australia
Acanthus ilicifolius Linn.	...	do
Aegiceras corniculatum Blanco.	...	India–Australia
Lumnitzera coccinea W. and A.	...	do
Avicennia officinalis Linn.	...	do
Avicennia alba Bl.	...	do
Phoenix paludose	...	India–Malaya
Nipa fruticans	...	do
Sonneratia griffithis Kunz.	...	do
S. acida Linn.	...	do
S. apetala Buch-Ham.	...	do
Bruguiera eriopetala W. and A.	...	do
B. parviflora W. and A.	...	do
B. cylindrica W. and A.	...	do
Kandelia rheedii Wight.	...	do
Lumnitzera sp.	...	India only
Avicennia marina Vierh.	...	do
Avicennia intermedia Griff.	...	Malaya only
A. lanata Ridl.	...	do
A. encalyptifolia	...	do
A. balanophora	...	Australia only

Floristics :

In 1796 Roxburgh obtained specimens from Sunderbans through Dr. Buchnan and Dr. William Carey and published his account in Hortus Bengalensis in 1814. Later on a comprehensive account of the flora of Sunderbans was given by C. B. Clarke before the Linnean Society of London in 1895. Afterwards Prain (1903) on Sunderbans, Blatter (1905, 1909) on Bombay and Kutch and Saurashtra and Haines (1925) on Mahanadi mangroves did taxonomic work which is of fundamental importance to plan future studies on mangrove habitat in various fields of Botany and related studies (Puri, 1960).

The author study on mangrove areas of the Sunderbans, Bombay, E. Godavari district and Saurashtra and Kutch have brought out the following points of interest :

1. There is no evidence of existence of *Bruguiera parviflera* on the Western coast.
2. The three *Avicennia* species are easily distinguishable on the basis of their leaf shape and size, flower size and colour of the bark.
3. In *Avicennia alba* there is a lot of variation in leaf shape and flower.
4. A new plant, probably *Lumnitzera* sp. belonging to the family Combretaceae has been recorded from E. Godavari mangrove region (Sidhu, 1961).
5. *E. agallocha*, previously considered to be an evergreen species, is deciduous in E. Godavari mangrove forest.

Ecology :

The occurrence of the important literature on the ecological studies of mangrove is that of Bowman (1920), Davis (1940), Copper and Pasha (1935) and Navalkar (1941, 48, 50, 52, 59). The present quantitative ecological studies and the review of the previous works show that *Avicennia alba* and *A. officinalis*, pure or mixed with *Acanthus ilicifolius* may be the pioneer species and in still other cases on the recently formed alluvial patches (within a period of about 50 years at E. Godavari) the pioneer species may be of those of the grasses including *Myriostachya wallichii.*

Cytology :

The cytology of mangroves was little known till the year 1957 when there was only a single report by Radermacher (1925) of *Nipafruticans*. Later no chromosome numbers in *Rhizophora mucronata*, *Avicennia alba*, *Ceriops candolleana* and *Sonneratia apetala* were worked out by Patil (1957), Raghavan (1958) and Raghavan and Arora (1958). The author has reported chromosome numbers in nine mangrove species all of which are new reports. The basic number of the family Rhizophoraceae is fixed to be 18. In genus *Suaeda* there exists inter as well as intra specific polyploidy. In general cytology of the mangrove points that mangroye species have comparatively higher chromosome numbers as compared to the corresponding chromosome number in mesic members of the same genus or the same family. The point is well illustrated in genus *Excoecaria*, *Aegiceras* and *Suaeda*. The polyploids in genus *Suaeda* are definitely more suited to the extreme conditions and have better potentialities to grow in new habitat as a result of the development of stronger soil and shoot system. Culture experiment are in progress to show this particular point of interest.

Anatomy

Anatomical studies have been carried on by Bowman (1921), Mullan (1931), Metcalfe (1931), Marco (1935), Peerson and Brown (1932), Panshin (1939), Singh (1941) and Chowdhury and Ghosh, but these studies have been centred on the wood anatomy, wood being the important plant part economically.

The present studies (Patil and Sidhu, 1960) on *Bruguiera parviflora* quite supports the observations by Mullan (1931). The anatomy of the mangroves in general shows a composite of characters, those of fresh water hydrophytes in the root portion and those of xerophytes in the aerial portion. This is the response to the peculiar type of habitat, which is physiologically dry. Moll and Janssomnis have concluded that in the mangroves the wood has more vessels per mm^2 and the vessel-diam. is comparatively smaller is comparison to those of the mesophytes as shown in the following table.

Mangrove species	No. of vessels /mm^2	Diam. of the vessels (in μ)	Non mangrove species	No. of vessels /mm^2	Diam. of the vessels (in μ)
Excoecaria agallocha	7–14	80	*Excoecaria vigata*	3–6	40–150
Sonneratia	35-50	35–75	*Duabanga*	4–5	130–400
Sonneratia apetala	18-32	135–150			
S. grifithii	34–50	85–100			
Aegicears corniculatum	200	–	Myrsinaceae	100	–

Physiology :

The mangrove species show a fairly wide range of their osmotic pressure value (of the cell sap) from 26–46 atmosphere. The studies have been carried by Walter (1935), Water and Steina (1936), Sen Gupta (1947) and Navalkar (1940). Navalkar concluded that osmotic pressure varies directly with (1) tide, (2) temperature, (3) inversally with the humidity and rainfall. Cooper and Pasha (1935) studied osmotic and suction pressure of *Acanthus ilicifolius*, *Avicennia officinalis* and *Sonneratia apetala*. They found that osmotic pressure and suction pressure of the mangrove species 4 rise from roots towards their leaves.

Stomatal frequency varies from 50–60 (*Ceriops candolleana*) to 850–950 (*Carapa moluccensis*). Stomatal index $(S.\ I = \frac{S}{E+S} \times 100)$ ranges from 1·5 (*C. candolleana*) to 22 (*Acanthus ilicifolius*). The studies show that stomatal index and frequency varies with the genus or a family *i.e.* constant in different species of the same genus.

It may be further remarked that stomatal index and frequency are controlled by genetic factors in mangrove however environs bring about the small variations.

Soil and foliar analysis :

Navalkar (1941, 50) has worked out the physical analysis of mangrove soils also determined the exchangeable bases of mangrove soils. In 1960 he published a paper on the humus content of mangrove soils and his data shows that the humus content varies from 1·25–1·61% and according to Satanarayan (1959) the organic matter of mangrove soil ranges from 2·7–2·21 % and pH from 7·63–8·5 in *Sonneratia Avicennia* communities.

The leaf analysis studies show that sodium content is quite high and varies from 5·58% to 1·23%. Sodium, Potassium and Calcium show a direct relation with ash. The species of mangroves have been divided into 3 categories based on their sodium content in leaf.

A. Species with more than 5% Sodium are *Salvadora persica, Avicennia marina.*

B. Species with 3–5% Sodium content are *Lumnitzera racemosa,* L. sp., *Avicennia alba, Acanthus ilicifolius, Ceriops candolleana.*

C. Species with 1–3% of Sodium content are *Eleopodendron inerme, Bruguiera caryophylloides, Avicennia officinalis, Excoecaria agallocha, Rhizophora mucronata, Aegiceras corniculatum, Derris uliginosa, Sonneratia apetala.*

The data further shows that species of *Avicennia* (*A. alba*) *A. officinalis, Rhizophora* and *Aegiceras* which grow near the sea or in the banks of the 'Canal's or 'rivers' have comparatively less ash and sodium. The comparative data of 3 *Avicennia* species starting from sea towards land is shown in the following table :

Species	Ash%	Na%
A. officinalis	14·84	2·332
A. alba	15·82	3·305
A. alba	19·4048	3·675
A. marina	30·40	5·0625

The species like *Sonneratia apetala, Ceriops candolleana, Bruguiera caryphylloides, L. racemosa* and *Salvadora persica* show a negative relation between Potassium and Calcium.

Species	Ca%	K%
S. apetala	1·12	0·31
Ceriops candolleana	2·04	0·531
A. officinalis	1·16	2·06
B. caryophylloides	2·48	0·61
L. racemosa	1·32	2·24
Salvadora persica	3·74	2·4

There is no specific relation between Potassium and Sodium as has been established in Carrots, Beets and other agricultural crops.

The species like *Avicennia marina* and *A. alba, Rhizophora mucronata* and *S. apetala* which are browsed upon contain less silica content, generally less than 1%. *Acanthus ilicifolius* and *E. agallocha* which are poisonous and are not browsed by cattles, help much in the early stages of growth of the seedlings of *Avicennia* and thus help the species to get a strong foot hold against action of waves and wind.

Embryology :

The embryology of the mangroves is not much done in India, however, there are reports from other countries on the embryology of *Rhizophore, Sonneratia* and *Aegiceras* (Cook 1907, Carrey 1934, Carrey and Fraser, 1932, Venkateswarlu 1935). The development of embryo in *Sonneratia* is of capsella type.

The plants show vivipary and hypocotyl elongates abnormally. Probably it is a result of higher salt concentration in the habitat and may have been imfriuted in the glumes of a particular species of mangroves in the remote past.

Conclusion :

The soil studies may lead to some more interesting correlation between habitat and the type of communities.

There have been questions like ; If paddy cultivation could be successful in mangroves areas ? Certainly, based on the observation in India, and Borneo (by Vanwijk, 1951), it is not very encouraging as it depletes the soil of its organic matter which alongwith the salt concentration results in the production of empty panicle. Drainage leads to a little more yield. Vanwijk (1951) remarks that 'mangrove soils in Borneo are poor in lime, magnesium is slighly higher and potassium is just sufficient. Further culture studies in this direction, particularly the effect of NaCl on the growth of paddy may throw a little more light on the possibilities of the reclamation of soils for paddy cultivation in mangrove areas. Its cultivation increases the chances of soil erosion and floods as it serves only as a temporary vegetal cover.

In the end suffice it would be to say that the above preliminary observation opens new problems in the various fields of botany especially cytology, ecology and soil studies of the mangroves. The study of seedling anatomy and soil analysis, the effect of different concentration of Sodium chloride on the growth of seedlings of different species of mangroves may pave a way for knowing the measures to be taken while regenerating the different species and afforesting the bare areas on the coast.

REFERENCES

Blatter, E. J. 1905. The mangroves of Bombay Presidency and its biology. *Jour. Bomb. Nat. History Soc.*, **16** : 644–56.

——— 1909. On the flora of Kutch, *i* and *ii*. *Ibid*, **18** (**4**) : 756–77 and **19** (**1**) : 157–176.

Bharucha, F. R. and Navalkar, B. S. 1942. *Jour. Univ. Bombay.*, **10** : 5

Bowman, H. H. M. 1920. Ecology and Physiology of Red Mangrove. *Proc. Amer. Phil. Soc.*, **56** : 589–672.

——— 1921. Histological variation in *Rhizophora mangle* L. *Rep. Mich. Acad. Sci*, **22** : 129–134.

Carrey, G. 1934. Further investigations on the embryology of Viviparous seed. *Proc. Linn. Soc. N. S. Wales.*, **59** : 392–410.

Carrey, G. and Fraser, L. 1932. The embryology and seedling development of *Aegiceras majus* Gaertn. *Proc. Linn. Soc. N. S. Wales*, **57** : 341–360.

Clarke, C. B. 1895. The Presidential address before the Linn. Soc., London, 1895.

Cook, M. T. 1907. The embryology of *Rhizophora mangle. Bull. Torrey Bot. Cl.*, **34** : 271–277.

Cooper, K. E. and Pasha, S. A. 1935. Suction Pressure of some species of mangrove vegetation. *Jour. Indian Bot. Soc.*, **14** (2) : 109–120.

Croizat, L. 1952. *Manual of Phytogeography.*

Davis, J. H. 1940. The ecology and geologic role of mangroves in Florida. *Publ. Carneg. Inst.*, **517** : 303–412.

Good, K. 1952. *The Geography of Flowering Plants*, Luganans, Green and Co., London.

Haines, H. H. 1925. *Botany of Bihar and Orissa*, Vol. I and II.

Macro, 1937. *Tropicl woods*, **44** : 1.

Metacalfe, C. R. 1931. The breathing roots of *Sonneratia* and *Bruguiera*, a review of the recent work by Troll and Dragendroff. *Kew Bull.*, **11** : 465–467.

Moll, J. W. and Janssonius, H. H. 1906–36. Mitkr. Holzes, 1–6.

Mullan, D. P. 1932. Observations on the biology and physiological anatomy of some Indian halopytes. *Jour. Indian Bot. Soc.*, **11** : 103–118 and 285–302.

——— 1933. Observations on the biology and physiological anatomy of some Indian halophytes. *Jour. Indian Bot. Soc.*, **12** : 165–182 and 235–253.

Navalkar, B. S. 1940. Studies on the ecology of mangroves. I. Determination of osmotic pressure of *Avicennia alba* Bl. *Jour. Univ. Bomb.*, **8** : 5

Navalkar, B. S. 1941. Studies on the ecology of mangroves. *Jour. Univ. Bomb.*, 9.

Navalkar, B. S. and Bharuch, L. R. 1948. Studies on the ecology of mangroves. II. *Jour. Univ. Bomb.*, **16** : 5

Navalkar, B. S. 1952. Succession of the mangrove vegetation of Bombay and Salsette Island. *Jour. Bomb. Nat. Hist. Soc.*, **50** : 157–61.

——— 1959. Studies on the ecology of mangroves. VII. Humus content of mangrove soil of Bombay and Salsette Island. *Jour. Univ. Bomb.*, **28** (3) : 6-10.

Panshin, A. J. 1932. An anatomical study of the woods of Philippine mangroves. *Philipp. Jour. Sci.* **48** : 143–207.

Patil, R. P. 1957. Chromosome number of some dicotyledons. *Curr. Sci.*. **27**: 140.

——— 1961. Studies on the mangroves of India. III. A note on the vegetation of Sazina Khali (Sunderbans). Communicated to *The Indian Forester*.

Patil, R. P. and Sidhu, S. S. 1961. Seedling anatomy of *Bruguiera parviflora* W. and A. *Proc. 48th India Sci. Congress*, Part **III** : 280.

Pearson, R. S. and Brown H. P. 1932. *Commercial timbers of India.* Government of India Publication Branch, Calcutta, Vol. I and II.

Prain, D. 1903. Flora of Sunderbans. *Rec. Bot. Surv. Ind.*, **2** (4) : 231.

Puri, G. S. 1960. *Indian Forest Ecology*. Oxford Press, India.

Radermacher, A. 1925. *Ann. Jard. Bot. Buiternz.*, **35** : 1.

Raghavan, R. S. 1958. Chromosome numbers in Indian Medicinal Plants. II. *Proc. Indian Acad. Sci.*, **49** : 239–244.

——— and Arora, C. M. 1958. Chromosome numbers in Indian Medicinal Plants II. *Ibid.*, **49** : 352–358.

Roxburgh, 1796. *Hortus Bengalensis*, published 1814.

Satayanarayanan, Y. 1959. Ecological studies of the Elephante Island. *Institut Francis De Pondicherry, Travana de la Section Scientifique et technique*, Tome I : 99–114.

Schimper, A. F. W. 1903. *Plant Geography upon a physiological basis*. Clarendon Press, Oxford, pp. 395–410.

Sen Gupta, J. C. 1942. Investigation of the annual variation of the water content, osmotic value and chloride fractions of some plants in port canning, Near Calcutta. *150th Ann. vol. Roy. Bot. Gard. Cal.* 1942.

Sidhu, S. S. 1961. Vegetation of East Godavari. *Proc. 48th Indian Sci. Congress*, Part **III** : 358–359.

——— 1961. Chromosomal studies on some mangrove species. *Proc. Indian Sci. Congress*, Part **III** : 302–303.

Singh, R. 1944. A contribution to the anatomy of *Salvadora persica* with special reference to the origin of included problem. *Jour. Indian Bot. Soc.*, **23** : 71–78.

Stern, W. L. and Voigot, G. K. 1959. Effect of salt concentration on growth of Red mangrove in culture. *Bot. Gaz.*, **121** (*i*) : 36–39.

Vanwijk, C. L. 1951. Soil survey of the tidal swamps of South Borneo in connection with agricultural practices. *Tectona*, **41** (2) : 75–110.

Venkateswarlu, J. 1935. A contribution to the embryology of Sonneratiaceae. *Proc. Ind. Acad. Sci.*, **5**.

Walter, H. 1935. *Zeitschr. Bot.*, **23** : 47.

——— 1936. *Ber. Schweiz. Bot. Gaz.*, **46** : 217.

Walter, H. and Steiner, M. 1936. *Zeit. Schr. F. Bot.*, **30** : 65.

NOTE ON FORESTRY AND HUMAN ECOLOGY

By

S. S. BUIT

Conservator of Forests, Thana Circle

Forests and forestry practices exercise considerable influence on man and his environments. Forests constitute one of the important natural resources meeting varied human requirements and needs of his cattle wealth. They exercise protective influence on soils, site, moisture conservation ; have ameliorative and protective effect on climate, precipitation, floods, wild life. Their development is closely linked to the agricultural and the industrial economy of the people, social and economic reconnaisance of man fulfilling his aesthetic recreational and other needs.

Whereas, man and his environments play vital role in forestry.

Grazing, fires, destruction of forests for diverse needs—rational or otherwise ; and planned forests management have seriously affected distribution, development and succession of forests. Much of this is common knowledge, but critical studies on various aspects of forestry and human environment are wanting.

I shall confine my attention to one important aspect, *viz.*, the problem of planned forest management in relation to agricultural and industrial economy. This is of vital significance in the rapidly developing national economy. Our total forest resources are inadequate to sustain increasing human needs of various forest produce, stabilise the agricultural economy and permit development of forest industries.

Our main problem is transformation of multicanopied, poorly stocked heterogenous forests composed of several species, few of which are valuable to economic stands. The human needs necessitate rapid transformation of the existing comparatively less valuable stands by monoculture or mixtures of few preferred species. The objective of planned management is the maximum production of economic species by complete site and space utilization, in harmony with biotic and abiotic environment. The stand development has to be dovetailed into related sectors of economy.

Forest is a dynamic living association continually changing in space and time. Typological investigations, based on the knowledge of individual components and of life communities in the forest, soil, climate, microclimate, microedaphic factors, micro-organisms in the soil and around, biotic and historical factors ; that determine the present composition of stands and the trends of development ; are an essential pre-requisite for elaborating scientific plans for judicious management in order to attain maximum productively in perpetuity.

Life dynamics of the forests based on such detailed studies must eventually determine all aspects of forest management and economy, right from fellings to regeneration, tending, thinnings, composition of stands, renovation or change of stands from valueless or less valuable to more valuable forests, afforestation of denuded lands, etc. The changes contemplated must fully harmonize with the stand environs.

The entire forest areas under planned management or otherwise should be classified into appropriate homogenous types or groups and sub-types which may constitute primary economic groups. Such groups will have a comparable identity of site conditions ; plant association and environment.

In the context of experience gained of scientific forest management elsewhere and in India too it must be fully recognised that forest economy must closely

correspond to forest types or economic groups. Where forest renovation or replacement of stands has been unrelated to stand environment, forest economy is gravely threatened as manifest in creation of evenaged pure stands in many European forests (data is lacking in India) ; clear cuttings in water sheds and catchments in all countries ; unrestricted satisfaction of local demand far grazing, firewood, humus, minor forest produce, etc. irrespective of the site and stand potentialities.

Apprehensions of site deterioration under pure teak plantations exist. Clearfellings of well stocked areas of Sal, teak and evergreen forests in the hope of quickly regenerating them have merely led to extension of blanks now refractory to growth. Regrowth of bamboos after gregarious flowering and plantations of pulpwood species have posed serious problems.

It is now recognised by all foresters in our country that some of the difficult problems of Indian forestry, such as the failure to regenerate naturally the principal types of forests, *viz*: Sal, teak, etc. ; acceleration or retardation of plant succession to suit the objects of management, soil erosion ; afforestation ; high mortality in plantations ; forest grazing, etc., are almost entirely due to lack of knowledge of plant ecology ; succession ; soil condition ; nutritional aspects of plants ; microclimate ; micro-organisms and microedaphic factors.

The need of scientific ecological studies of plant communities and their succession to enable correct classification of forest types or economic groups, therefore, becomes imperative.

The experts will have to decide the lines on which typological investigations should be carried out and the precise concept of forest types (*viz* : phytocenosis ; biocenosis or biogeocenosis) since under identical site conditions different plant communities may occur or similar plant communities may be observed under diverse site conditions. Biotic influences have quite often changed the original types beyond recognition.

The present classification of types by Champion is very broad and can only serve as a basis for future studies. Whethes the types should be designated by the main arboreous stock in the stand composition (*viz* : Teak—*Terminalia-Butea* ; Teak —*Boswellia serrata* ; *Chloroxylon* ; Teak—*Hardwickia*) or by the principal species and the under growth (*viz*: Teak—*Chionachne barbata* ; Teak—*Imperta* ; Teak—*Petalidium*) signifying site conditions is a matter of technical detail.

Whatever the basic concept of classification and technical details of classification, the different forest types should indicate reasonably accurately the stand distribution, environments and site conditions and each type shall be a fairly homogenous plant community with comparable identity wherever the type occurs.

The knowledge of the natural properties of the types or economic groups and rational application of appropriate forestry measures closely related to site conditions and environments of such stands will permit their transition to fully productive stands of desired economic, site suitable species and thus aid national economy and industrial development on a long term basis. A map of forest types of the country will be of immense value for current orientation of the forestry measure.

It is advisable that organisation adequately staffed and necessary scietific investigations are initiated early and useful data should be made available to the forest services as quickly as possible to guide the forestry practices. This will fill a void in scientific studies confronting us on the important aspect of Forestry and Human Ecology.

STUDIES ON ASPERGILLI AND PENICILLIA OF THE RHIZOSPHERE OF SOME CROP PLANTS

By

B. S. MEHROTRA, DINESH KUMAR *and* V. P. AGNIHOTRI

Department of Botany, University of Allahabad, Allahabad, India

INTRODUCTION

While introducing the term *'rhizosphere'* in 1904 Hiltner described it as that region of the soil which came under the influence of a plant root system. The extent to which the soil is influenced by root varies with the type and age of the plant, soil conditions, topography and climatic conditions. The *rhizosphere* is generally characterised by greater microbial activity than the surrounding soil. This fact has been confirmed by various workers (Starkey 1929 *a*, *b*, *c*, 1931, 1938). Information on the microflora of root zone has been provided by several workers during the last thirty years (Timonin 1940 ; Katznelson 1946 ; Timonin and Lochhead, 1948 ; Vozniakovskaia 1948 ; Katznelson *et al* 1955 ; Agnihotrudu 1955 ; Bhuvaneshwari and Rao 1957 ; Bhuvaneshwari 1958 ; Sulochana 1958).

It is believed that intensified microbial activity in the rhizosphere is due to liberation of wide range of metabolites by the actively growing roots during their normal metabolism. These metabolites, which are known as root exudates, constitute both inorganic and organic compounds. In general the nature and amount of these root exudates differs widely with the different species of plants. Of the various constituents of root exudates, amino acids, sugars and organic acids play a major role in determining the microflora of a rhizosphere. Significant work on the root exudates and their influence on the rhizosphere population has been done by West (1939), Lundegardh and Stenlid (1944), Katznelson, Rouatt and Payne (1954), Rovira (1956 *a*, *b*) and Andal *et al.* (1956).

The present study deals with certain ecological aspects of Aspergilli and Penicillia. Their occurrence in the rhizosphere and non-rhizosphere soils of different crop plants at three different phases of growth have been investigated. Further, the nature and role of the root exudates and other factors governing the occurrence of these organisms have also been studied.

MATERIALS AND METHODS

Isolation of fungi was done by the soil dilution and plate count method (Timonin, 1940). In studying the rhizosphere population blocks of soil containing plant roots were cut out and gently crushed with as little tearing as possible. The roots were taken out carefully and were then shaken to remove the superfluous soil. They were placed, along with the adhering soil particles in flasks containing 100 ml. of sterile water. The roots were then thoroughly shaken on rotatory shaker. Later suitable dilutions of the above soil suspension (1/100, 1/1000, 1/5000) were prepared by adding sterile distilled water. The following media were used for isolation : (*a*) Czapek agar, pH adjusted to 4·5, (*b*) As above but pH unadjusted and containing rose bengal (1 : 15000) and *streptomycine* (30γ/ml.), (*c*) Hay–infusion agar (Hay, 50 g/l ; K_2HPO_4, 2g). One ml. of each of the above dilutions was poured in each of the Petridishes containing sterilized media used

for the isolation work. The dishes were then incubated for 3–5 days at room temperature. During this period all Aspergilli and Penicillia appearing in the Petridishes were picked up. Their pure cultures were made by single head culture and identifications were made with the help of relevant literature. Where ever necessary comparisons with the type cultures were also made.

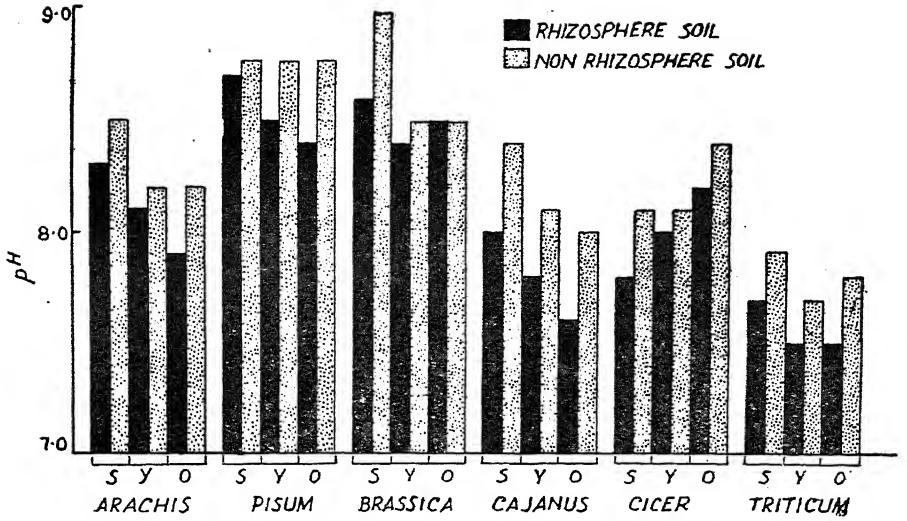
The same procedure was employed for isolating these molds from soil away from the rhizosphere. The pH of both rhizosphere and non-rhizosphere soil was determined by Blackman's electric pH meter while the moisture content was determined by the method advocated by Robinson (1922).

Andal *et al* (1956) technique was used for the extraction and quicker concentration of the root exudates. The root exudates thus obtained were chromatographically analysed for amino acids, sugars and organic acids. For amino acids two dimensional paper chromatography described by Consdon *et al.* (1944) was followed. The chromatograms were run in phenol : ammonia : water (80 : 1·5 : 20) in one direction and in butanol : acetic acid : water (4 : 1 : 5) in other. After drying, the chromatograms were sprayed with ·1% ninhydrin in *n*-butanol. They were then heated at 90°C for 10–15 minutes. The bands were identified by comparing their *Rf* values with those of known amino acids. For sugars, partition circular paper chromatography, described by Ranjan *et al.* (1955) was employed. The chromatograms were run in *n*-butanol : acetic acid : water (4 : 1 : 5) and were sprayed with a mixture of alanine diphenylamine phosphate (5 vols. of aniline, 5 vols. of 4% diphenylamine and 1 vol. of phosphoric acid). The *Rf* values of various bands thus obtained was recorded and compared with those of known sugars. Paper chromatography technique of Lugg and Overell (1947) was used to detect the presence of organic acids in root exudates. In this case the chromatograms were run in *n*-butanol : formic acid : water (? : 10 : 5) and then they were sprayed with ·04% bromo-phenol blue in 90% alcohol. The bands were compared with those obtained from the spots of the known organic acids.

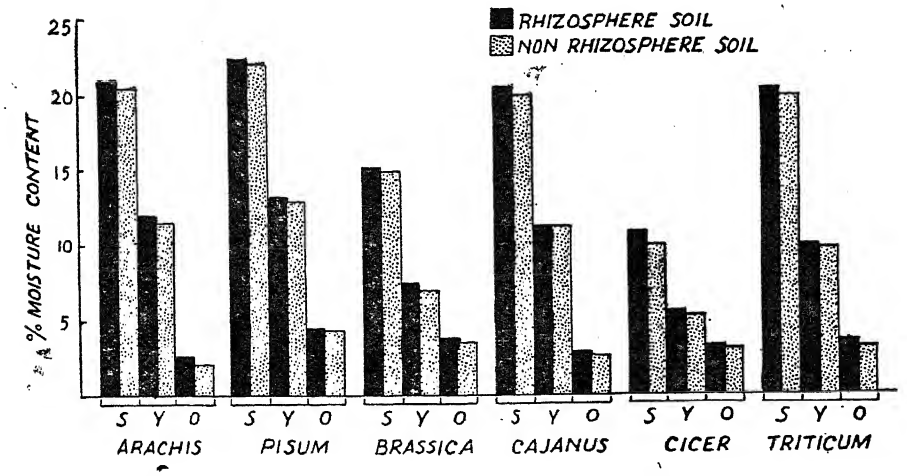
OBSERVATIONS

(*a*) *Occurrence of Aspergilli and Penicillia during different stages of growth of some crop plants.*—The total number of Aspergilli and Penicillia isolated during the course of present study are listed in table 1. Table 2 shows the occurrence of these molds in rhizosphere and non-rhizosphere soils of different crops at different ages of growth, *viz.*, seedling stage, young stage (at the time of bloom) and old stage (when the fruits were mature).

It is clear from the tables 1 and 2 that number of Aspergilli and Penicillia were more in the rhizosphere than in the surrounding soil. There was a marked rhizosphere effect in the young stage of growth of these plants while it was least when plants grew old. The largest number of species of both Aspergilli and Penicillia were obtained from the rhizosphere of *Cicer arietinum*. However, *Brassica compestris* had the least number of these molds in its rhizosphere.



1. Histogram showing the pH of rhizosphere and non-rhizosphere soils at three different stages of growth (S = seedling stage ; Y = young stage ; O = old stage) of different crop plants.



2. Histogram showing the percentage moisture content of rhizosphere and non-rhizosphere soils at three different stages of growth (S = seedling stage ; Y = young stage ; O = old stage) of different crop plants.

TABLE 1

Names of Aspergilli and Penicillia isolated from different rhizosphere and non-rhizosphere soils

S. No.	Name of the mold
1.	*Aspergillius niger* van. Tieghem
2.	*A. niger* van Tieghem mut. *cinnamomeus* (Schiem) n. comb.
3.	*A. flavus* Link
4.	*A. panamensis* Raper and Thomsis
5.	*A. luchuensis* Inui
6.	*A. rugulosus* Thom and Raper
7.	*A. nidulans* (Eidam) Wint
8.	*A. fumigatus* Fresenius
9.	*A. tamarii* Kita
10.	*A. carneus* (v. Tiegh) Block emend
11.	*A. ustus* (Bainier) Thom and Church
12.	*A. candidus* Link
13.	*A. sydowi* (B. and S.) Thom and Church
14.	*A. oryzae* (Ahlburg) Cohn.
15.	*A. terreus* Thom
16.	*A. ochraceus* Wilhelm
17.	*A. japonicus* Saito
18.	*Penicillium notatum* Westling
19.	*P. frequentans* Westling
20.	*P. herquei* Bainier and Sartory
21.	*P. steckii* Zaleski
22.	*P. citreo-viride* Biourge
23.	*P. purpurogenum* Stoll
24.	*P. rubrum* Stoll
25.	*P. variabile* Sopp
26.	*P. funiculosum* Thom

(*b*) *pH and Moisture content of the rhizosphere and non rhizosphere soils.*—Changes in pH and moisture content in rhizosphere and non-rhizosphere soils during different stages of growth of different crop plants, are indicated in Fig. 1 and 2

respectively. It is clear from Fig. 1 that the soils had an alkaline reaction, pH ranging from 7·0 to 9·0, and that the pH of rhizosphere soils varied slightly during the different stages of growth of the roots. In the case of *Cicer arietinum* pH of rhizosphere soil increased with the age of the plant while in other plants, *viz.*, *Cajanus cajan*, *Pisum sativum*, *Arachis hypogea*, *Brassica compestris* and *Triticum vulgare* a decrease in pH was recorded. Moreover, with the gradual aging of the plant and accompanying dryer and warmer weather conditions, the moisture content on the whole decreased considerably.

TABLE 2

List of fungi isolated from the rhizosphere and non-rhizosphere soils of different plants at three stages of their growth. The species of Aspergilli and Penicillia are represented by numbers which correspond to those given in Table 1 to the different specie

Crop	Stage of plant growth	Rhizosphere soil		Non-rhizosphere soil	
		Aspergilli	Penicillia	Aspergilli	Penicillia
(*a*) *Cajanus cajan*	Seedling	1,3,6,7	19,20,24,25	1,8,15	—
	Young	1,2,3,8,11,12,15	19,20,23,24,25	1,3,8,11,12	23,24,25
	Old	1,2,3,6,8,14	19,23	1,3,8	23,25
(*b*) *Tritictum vulgare*	Seedling	1,3,6,7,11	21,23,25	1,3,11	—
	Young	1,2,3,6,11,13,17	19,21,23,25,26	1,3,6,7,8,11	19,21,23,25
	Old	1,6,8,	19,21,24	1,3,8	20,21,26
(*c*) *Pisum sativum*	Seedling	1,3,5,7,8	19,23,24,25	1,2,7,10	—
	Youug	1,3,4,6,7,8,11	19,20,21,23,24	1,3,8,11,17	18,19,21
	Old	1,6,7,8,15	20,21,25	1,7,8	18,19,21
(*d*) *Arachis hypogea*	Seedling	1,3,6,7,8,11	23,24	1,8,11	—
	Young	1,3,4,5,6,8,15,16	20,21,22,23,25	1,3,5,8,9,11	19,22,24,25
	Old	1,3,8,11,15	21,22,25	1,3,11	24,25
(*e*) *Brassica compestris*	Seedling	1,3,5,7,11	19,21,23	1,4,6	—
	Young	1,3,8,11,15,16	20,21,22,26	1,3,11,13	23,24,25
	Old	1,3,6,7,8,15	21,23	1,14,16	18,20,23
(*f*) *Cicer arietinum*	Seedling	1,3,5,11,15,16	20,23,24,25	1,3,5,11	—
	Young	1,3,5,7,8,9,10,11, 12,14	19,21,22,23,24, 25	1,3,8,10,12	18,19,22,26
	Old	1,3,6,8,14,15	23,24,25	1,3,8	19,20,22

(*c*) *Analysis of the root exudats.*—The sugars, amino acids and organic acids, detected by chromatographic analysis, in the young roots of the different plants, under study, are given in Table 3.

As evident from table 3, asparagine, glutamic acid, aspartic acid, glycine, serine leucine, isoleucine and valine were present in the root exudates of all the crop plants. Alanine was present in *Arachis*, *Cicer*, *Pisum* and *Cajanus* while tyrosine was present in *Triticum* and *Cajanus* only. Presence of glutamine was recorded in *Arachis*, *Triticum*, *Cajanus* and *Pisum* where it it was present in a very large quantity as shown by the intensity and area of the band. Proline was present in *Arachis* and *Triticum*, while arginine was present in *Arachis*, *Triticum* and *Cajanus*. Histidine and Gamma-amino butyric acid were absent from the root exudates of *Arachis*, and *Cajanus* and *Brassica*, *Cicer* and *Cajanus* respectively.

TABLE 3

Table showing absence (—) and presence (+) of a number of amino acids, sugars and organic acids in the exudates from young roots of different plants.

Root exudate constituent	*C. cajan*	*T. vulgare*	*P. sativum*	*A. hypogea*	*B. compestris*	*C. arietinum*
(*a*) *Amino acids*						
Asparagine	+	+	+	+	+	+
Glutamic acid	+	+	+	+	+	+
Asparatic acid	+	+	+	+	+	+
Glycine	+	+	+	+	+	+
Serine	+	+	+	+	+	+
Alanine	+	—	+	—	—	+
Tyrosine	+	+	—	—	—	—
Threonine	—	—	+	—	—	—
Glutamine	+	+	+	—	—	+
Valine	+	+	+	+	+	+
Leucine	+	+	+	+	+	+
Iso-leucine	+	+	+	+	+	+
Proline	—	+	—	+	—	—
Arginine	—	+	—	+	—	+
Histidine	—	+	+	—	+	+
γ-aminobutyric acid	—	+	+	+	—	—
(*b*) *Sugars*						
Sucrose	+	+	+	+	+	+
Glucose	+	+	+	+	+	+
Fructose	+	—	+	+	+	+
Maltose	—	+	—	—	—	+
(*c*) *Organic acids*						
Fumaric	+	+	+	+	—	+
Succinie	—	+	+	+	—	—
Malic	+	+	+	+	+	+
Citric	+	+	—	—	+	+
Oxalic	+	+	—	—	+	+
Tartaric	—	+	—	—	+	—

Of the 4 sugars detected sucrose and glucose were present in root exudates of all the crop plants. Fructose was present in all except *Triticum*. The presence of maltose was recorded only in *Cicer* and *Triticum*.

Malic and citric acids were the most common of all the organic acids detected in the present study. However, fumaric acid was absent only in *Brassica*, while succinic acid was absent in *Cajanus*, *Cicer* and *Brassica*. Citric acid was present only in *Cajanus*, *Cicer*, *Triticum* and *Brassica* while tartaric acid was detected in *Pisum*, *Triticum* and *Brassica* only.

DISCUSSION

The present study shows that the number of Aspergilli and Penicillia in rhizosphere were found to be more than in the soil away from it. The reason for the greater microbial activity in the rhizosphere region has been ascribed to the presence of a number of inorganic and organic excretion products found in the roots during the normal course of their development. Many compounds like amino acids (Katznelson *et al.*, 1955 ; Rovira, 1956 *a*, Andal *et al*,. 1956), sugars, adenylic acids and nucleotides (Lundergardth and Stenlid, 1944). organic matter including orgnaic nitrogen (Lyon and Wilson, 1921), have been found to be excreated. Rovira (1956 *a, b*), while reporting a good number of amino acids and sugars from the root exudates of Oats and Peas, grown under aspetic conditions, concluded that the exudates have got an undoubted role to play in the stimulation of microorganisms on and around the root regions. While analysing the root exudates of 6 crop plants during the course of the present study a total of 16 amino acids, 4 sugars and 6 organic acids were detected. However, the pattern of composition of root exudates of these different plants was different and this explained the difference in number of these molds occruring in the rhizosphere of varions crop plants. *Cicer arietinum* which had 12 amino acids (asparagine, glutamic acid, aspartic acid, glycine, serine, alanine, glutamine, valine, leucine, isoleucine, arginine and histidine) all the four sugars (sucrose, glucose, fructose and maltose) and four out of six organic acids (fumeric, malie, citric and Oxalic) exerted the greatest rhizosphere effect for both Aspergilli and Penicillia. The least rhizosphere effect for both the groups of these molds was noted in the case of *Brassica compestris* which had only 9 amino acids in its root exudate and that in low concentrations.

The presence of greater number species of Aspergilli and Penicillia in the rhizosphere soil of young plants than in the seedlings could be due to the prevailing optimum moisture conditions during the seedling stage. Katznelson and Routt (1957) and Lochhead (1959) have also stated that within a moisture range suited to plant growth the number of rhizosphere organisms are greater at lower than higher moisture level.

With the aging of the roots the number of Aspergilli and Penicillia has been reduced and mostly the cellulose decomposing species have been found to predominate at that phase of development. This reduction in number may be due to paucity of the root exudates or the right type of nutrients in the exudate. Further, the moisture and temperature conditions were unfavourable for the development of fungi at that stage. The predominence of cellulose decomposing species may be due to the presence of cellulose in the rhizosphere resulting from the sloughing off of epidermal cells from the roots in old age. This aspect of the present study needs further investigation.

The lowering of pH in the rhizosphere soil has been generally ascribed as due to the decomposition of sloughed off epidermal cells. The presence of organic and amino acids in the root exudates, as a matter of fact, also play an important part in lowering the pH of the rhizosphere.

SUMMARY

Aspergilli and Penicillia from the rhizosphere and non-rhizosphere soils of some important cultivated crop plants, *viz.*, *Cajanus cajan*, *Triticum vulgare*, *Pisum sativum*, *Arachis hypogea*, *Brassica compestris* and *Cicer arietinum*, have been isolated. The following 17 species of *Aspergillus* and 9 species of *Penicillium* were found. *Aspergillus niger* van Tieghem, *A. niger* van Tieghem mut *Cinnamomeus* (Schiem) n comb., *A. flavus* Link, *A. panamensis* Raper and Thom, *A. luchuensis* Inui, *A. rugulosus* Thom and Raper, *A. nidulans* (Eidam) Wint., *A. fumigatus* Fresenius, *A. tamarii* Kita, *A. carneus* (v. Tiegh) Bloch, *A. ustus* (Banier) Thom and Church, *A. candidus* Link, *A. sydowi* (B. and S.) Thom and Church, *A. oryzae* (Ahlburg) Cohn, *A. terreus* Thom, *A. ochraceus* Wilhelm, *A. japonicus* Saito, *Penicillium notatum* Westling, *P. frequentans* Westling, *P. herquei* Bainier and Sartory, *P. steckii* Zaleski, *P. citreoviride* Biourge, *P. purpurogenum* Stoll, *P. rubrum* Stoll, *P. variabile* Sopp and *P. funiculosum* Thom.

It been has observed that the pH in the region of rhizosphere was lower and moisture content was higher than in the soil away from it. Further, the maximum number of these organisms were found in the rhizosphere of young plants. The chromatographic analysis of the root exudates of young plants revealed the presence of 16 amino acids, 4 sugars and 6 organic acids. However, the composition of root exudates of different crop plants was different.

LITERATURE CITED

Agnihotrudu, V. 1955. Incidence of Fungistatic organism in the rhizosphere of Pigeon Pea (*Cajanus cajan*) in relation to resistence and susceptibility to wilt caused by *Fusarium udum*. *Naturwissenschaften*, **42** : 374.

Andal, R., Bhuvaneshwari, K. and Subba Rao, N. J. 1956. Root exudates of Paddy. *Nature, Lond*, **178** : 1063.

Bhuvaneshwari, K. 1956. Root exudates in relation to rhizosphere effect. *Memoirs of Ind. Bot. Soc.* **Memo**, **1** : 98–101.

Bhuvaneshwari, K. and Subba Rao, N. S. 1957. Root exudates in relation to rhizosphere effect, *Proc. Ind. Acad. Sci.*, **115** : 299–301.

Consdon, R., Gardon, A. M. and Martin, A. J. P. 1944. Qualitative analysis of Protein. A. Partitition chromatographic method using Paper. *Biochem. J.* **35** : 224.

Hiltner, L. 1904. Uber neuere Erfahrungen und Probleme auf dem Gebiet der Bodenbakleriologie und unter besonderer Berucksichtigung der Giru ndungung und Brache. *Arbdtsch. Landw Ges.*, **98** : 59–78.

Katznelson, H. 1946. The rhizosphere effect of Mangels on certain groups of soil micro-organism. *Soil Sci.*, **62** : 343–354.

Katznelson, H., Rouatt, J. W. and Payne, T. M. B. 1954. Liberation of amino acids by plant roots in relation to dessication. *Nature, London*, **164** : 1110.

——— 1955. The liberation of amino acids and reducing compounds by plant roots. *Plant and Soil*, **7** : 35–48.

Katznelson, H. and Rouatt, J. W. 1957. Manometric studies with rhizosphere and non-rhizosphere soil. *Cand. J. Microbiol.* **3** : 673-678.

Lochhead, A. G. 1959. Rhizosphere micro-organisms in relation to root disease fungi. *Plant Pathology—problems and Progress,* (1908–1958) : 327–338.

Lugg, J. W. and Overell, B. T. 1947. Partition chromatography of organic acids on paper sheet support. *Nature.* **160** : 87.

Lundegardh, H. and Stenlid, G. 1944. On the exudations of nucelotides and flavanones from living roots. *Ark. Botanik,* **31A** : 1.

Lyon, T. L. and Wilson, J. K. 1921. Liberation of organic matter by roots of growing plants. *Cornell, N. Y. agr. Expt. sta. Mem.,* **40** : 1–44.

Ranjan, S., Govindjee and Lalorya, M. M. 1955. Cromatographic studies on the amino acid metabolism of healthy and deceased leaves of *Croton sparciflora. Proc. Nat. Inst. Sci.,* **21** : 42–47.

Robinson, G. W. 1922. *Jour. Agri. Sci.* 306–32 .

Rovira, A. D. 1956*a*. Plant root excretions in relations to the rhizosphere effect I. The nature of root exudates from Oats and Peas. *Plant and Soil.* **7** : 178–94.

——— 1956*b*. A study of the development of root surface microflora during the initial stages of plant growth. *J. appl. Bacterial.* **19** : 72–79.

Starkey, R. L. 1929*a*. Some influence of the development of higher plants upon the micro-organisms in the soil I. Historical and Introductory. *Soil Sci.,* **27** : 310–334.

——— 1929*b*. Some influence of the development of higher plant upon the micro-organisms in the soil II. Influence of the stage of plant growth upon abundance of organisms. *Ibid.* **27** : 355–377.

——— 1929 *c*. *Ibid.* III. Influence of the stage of plant growth upon some activities of the organism. *Ibid.* **22** : 433–444.

Starkey, R. 1931. Some influence of the development of higher plants upon the micro-organism in the soil IV. Influence of promimity to roots in abundance and activity of micro-organisms. *Soil. Sci.,* **32** : 367–393.

——— 1938. Some influence of the development of higher plants upon the micro-organism of the soil VI. Microscopic examinaiion of the rhizosphere *Ibid.* **45** : 207–249.

Sulochana, C. B. 1958. Root exudates. *Memo Ind. Bot. Soc.* **Mem.** *No.,* **1** : 98–101.

Timonin, M. I. 1940. The interaction of higher plants and soil micro-organisms I. Microbial. population of rhizosphere of seedling of certain cultivated plants. *Cand. J. Research,* **18** : 307–317.

Timonin, M. I. and Lochhead, A. G. 1948. Distribution of micro-organisms in the rhizosphere of the root system. *Trans. Roy. Soc. Can.,* II–**42** : 175–187.

Vozniakovskaia, Y. M. 1948. The influence of the root system of wheat on the soil microflora. *Microbiol. (U. S. S. R.),* **17** : 458–462.

West, P. M. 1939. Excretion of thiamine and biotin by the roots of higher plants. *Nature,* **144** : 1050–1051.

THE EFFECT OF DECOMPOSITION OF MATURE LEAVES AND LITTER OF SAL (*SHOREA ROBUSTA* GAERTN. F.) ON GARDEN AND LATERITIC SOILS

By

N. K. JAIN

*Department of Botany, Government College, Guna**

INTRODUTION

The role of litter in soil development and maintenance of soil fertility has been recognised by many workers (Pearsall 1945, Russel 1950, Thompson 1952, Barshad 1955 and Misra and Puri 1954). Lutz and Chandler (1955) believe that leaf fall exerts an important influence on physical, chemical and biological characters of soil and thus balances nutrients of forest soils. Puri (1952) observed that calcium and magnesium of soils under Sal are mostly returned to it by the fall of leaf litter. Further, Puri (1954) determined that 2·4 tons of organic matter per acre was produced by the fall of leaf litter on the forest floor of Sal at Dehra Dun.

While investigating the nutritional requirements of Sal, the present investigator has studied the role of Sal leaf litter, in changing physico-chemical composition of garden and lateritic soils.

METHODS

The podological behaviour, following the decomposition of leaf litter and mature leaves of Sal was observed in garden soils mixed with organic manure and red soils (lateritic) from the top of a basaltic hillock. The soils were kept in earthen pots. In all forty such pots were prepared, half of them were filled with garden soils and the other half with red soils. Of these 10 pots were covered with mature leaves and 10 with litter. Equal amount of (500 gms.) dry leaf litter and mature leaves of Sal were taken in each case. The pots were watered daily. The mode of decomposition of mature leaves and leaf litter in both the types of soil were recorded monthly for the period of one year by noting the changes in the chemical composition of the soils. The soil samples were taken from 6 to 15 cms. depth after removing undecomposed Sal leaves from the surface. This horizon of soil represents 'A' horizon having maximum biological activities and is subject to other forces of the environment (*cf.* Manual of Soil Survey, 1951). The horizon will be referred here as 'decomposing zone'. Leaves used in the experiments were procured from Palampur range of Punjab and Singra range of Assam.

Before setting the experiment soils and leaves were analysed. The soils were analysed for pH, organic, carbon, total nitrogen, and exchangeable calcium, magnesium, phosphate and iron. Leaves were analysed for ash, silica, nitrogen, calcium and iron. The methods for detailed chemical analysis of soils and leaves were those given by Piper (1947), Loomis and Shull (1937), Robinson, McLean and Williams (1929) and Yoe (1928).

---

*The work was undertaken at the Botany Department of Mahakoshal Mahavidyalaya, Jabalpur.

OBSERVATIONS

The initial characters of Sal leaves and litter are presented in table 1 and 2.

TALBE 1

Chemical Constituents of Sal Leaves before keeping for decomposition
(In percentage of dry weight)

Locality	Ash	Silica oxide	Calcium	Nitrogen	Iron
Punjab					
Palampur range					
Mature leaves	6·20	0·121	1·653	0·0008	0·01645
Leaf litter	5·25	0·621	1·075	0·0016	0·02150
Assam					
Singra range					
Mature leaves	3·90	0·171	0·537	0·0057	0·01075
Leaf litter	4·05	0·371	1·075	0·0041	0·09050

It was observed that the mature leaves and leaf litter disappeared from the soil surface in about 8 months.

RESULT

From the above observations it is noted that with the start of decomposition of leaves slight decrease in pH is recorded which is followed by an increase in subsequent months. Other important bases like calcium, etc., behave similar to it, whereas total nitrogen progressively increases with the time.

DISCUSSION

With the fall of leaves, decomposition almost starts under the influence of various agents like water, air, plant enzymes, animal and micro-organism. First three of these agents according to Waksman (1938) bring about oxidation and hydrolysis of the certain compounds. Animal and other micro-organisms reduce the amount of organic debris during chemical decomposition. The amount gets mixed with inorganic soil material. During initial oxidation and hydrolysis of organic debris certain acids are released in very small quantities which will naturally decrease pH of the superficial soils under decomposition. Animal activity will gradually make the organic debris soluble and upon mixing with the inorganic soil it will appear to increase the amount of exchangeable bases. This will take place at the decomposing zone. As a result of progressive watering soil solutions will come down the decomposing zone and enrich the soil lower below; whereas itself becoming poorer in bases. At the time when bases are made soluble in the decomposing zone, pH of the zone should record an increase. However, with the leaching down of the bases from this horizon the pH may again show a fall.

Further upon decomposition of organic bases subsequent to the activity of organic carbon, nitrogen will gradually get accumulated in the superficial layers and then will get washed down upon watering. Thus nitrogen percentage will continue to decrease in the soil below as decomposition proceeds.

TABLE 2

The effect of decomposition of Sal leaf litter on garden and lateritic soils (In perceatage of dry soils), the figures and average of the replicates.

Soil Type	I—IN GARDEN SOIL												
Nature of leaves spread	Leaf litter Palampur (Punjab) Values are average of 10 replicates						Mature Leaves Singra (Assam) values are average of 10 replicates						
Soil character and date	pH value	Calcium	Organic Carbon	Nitrogen	Iron	Magnesium	Phosphate	pH value	Calcium	Organic Carbon	Nitrogen	Iron	Magnesium	Phosphate
Initial Soil Characters 9.4.1957	6·95	0·179	3·150	0·0064	0·000082	0·004675	0·0181000							
23.4.1957	6·75	0·199	0·279	0·0113	0·004125	0·07081	0·0137500							
1.6.1957	6·90	0·131	0·480	0·0064	0·000103	0·004590	0·025250							
9.7.1957	6·90	0·1492	0·450	0·0032	0·000078	0·004632	0·010250							
2.8.1957	7·0	0·136	0·504	0·0032	0·000421	0·004803	0·016370							
2.9.1957	7·40	0·321	0·462	0·0032	0·010313	0·000867	0·002537							
6.9.1957								7·05	0·233	0·270	0·0032	0·008738	0·004547	0·003256
2.10.1957	7·30	0·216	0·270	0·0064	0·004436	0·00476	0·012250	6·70	0·192	0·860	0·0072	0·005138	0·004718	0·014125
2.11.1957	7·25	0·204	0·053	0·0077	0·006000	0·00476	0·12750	7·04	0·180	0·558	0·0064	0·004538	0·00124	0·015875
2.12.1957	7·00	0·168	1·314	0·0077	0·001500	0·001300	0·003063	6·95	0·168	0·531	0·0024	0·001049	0·001279	0·001880
2·12.1957 Soil from bottom	6·40	0·120	0·504	0·0077	0·001423	0·000549	0·002250							
2.1.1958	6·65	0·182	0·537	0·0097	0·000320	0·000540	0·002237	6·90	0·217	0·0339	0·0098	0·000240	0·011475	0·001725
2.2.1958	7·00	0·194	0·690	0·0290	0·000054	0·002937	0·00575	6·90	0·239	0·672	0·0340	0·000203	0·002958	0·005475
2.3.1958	6·85	0·171	0·578	0·0369	0·003090	0·00825	0·01775	6·50	0·296	0·087	0·0369	0·000177	0·000247	0·006573
2.4.1958	7·05	0·182	0·840	0·5460	0·000758	0·000245	0·006375	6·90	0·182	0·768	0·0546	0·001155	0·00024	0·006315

Soil Type	LATERITIC SOILS												
Nature of leaves spread	Litter Singra (Assam)							Mature Leaves Palampur (Punjab)					
Soil character and date	pH value	Calcium	Organic Carbnn	Nitrogen	Iron	Magnesium	Phosphate	pH value	Calcium	Organic Carbon	Nitrogen	Iron	Magnesium	Phosphate
Initial Soil Characters 9.4.1957								6·80	0·167	0·393	0·0096	0·000104	0·008720	0·015050
23.4.1957								6·50	0·167	1·005	0·0064	0·004238	0·009010	0·109250
1.6.1967								6·80	0·189	0·375	0·0032	0·000086	0·004037	0·032250
9.7.1957								6·65	0·194	0·249	0·0032	0·000089	0·003698	0·010370
2.8.1957								6·80	0·202	0·216	0·0096	0·000084	0·006205	0·010125
2.9.1957								7·25	0·321	0·189	0·0073	0·004898	0·00162	0·015625
6.9.1957	6·80	0·179	0·108	0·0070	0·007073	0·000200	0·00060							
2.10.1957	6·15	0·168	0·381	0·0032	0·006750	0·005355	0·15125	7·3	0·250	2·10	0·0096	0·002351	0·004473	0·014125
2.11.1957	6·75	0·170	0·510	0·0077	0·005513	0 001288	0·019875	7·2	0·264	0·603	0·0032	0·004375	0·003357	0·0128388
2.12.1957	4·95	0·080	0·594	0·0077	0·003428	0·000544	0·006625	6·95	0·218	0·75	0·0064	0·003675	0·001313	0·001875
2.12.1957 Soil from bottom								5·95	0·084	0·273	0·0032	0·002213	0·00055	0·002125
2.1.1958	5·45	0·148	1·002	0·0314	0·004320	0·002953	0·001375	6·90	0·239	0·480	0·0026	0·000285	0·00045	0·001375
2.2.1958	6·80	0·274	0·756	0·0341	0 000163	0·007225	0·01350	6·75	0·319	0·804	0·00380	0·008037	0·002958	0·005375
2.3.1958	6·65	0·217	0·486	0·0145	0·000465	0·000241	0·00637	6·55	0·228	0·291	0·0132	0·001065	0·0087	0·001000
2.4.1958	7·10	0·182	0·360	0·0518	0·001950	0·002197	0·0065	6·70	0·239	2·496	0·0378	0·001576	0·0025	0·006650

The foregoing assumption partially based on the experimental data by others appears to hold good in explaining the trends of decomposition of Sal leaves and litter in the present sets of experiments. If we suppose this as the mechanism of decomposition of organic debris, then it will appear that soil samples analysed by Upadhyaya (1955) were only from the superficial layers and that is probably the reason why in his observations he has recorded removal of minerals from the soils as a result of addition of organic matter.

ACKNOWLEDGEMENTS

The author is indebted to Dr. S. C. Pandeya, Central Botanical Laboratory, Botanical Survey of India, Allahabad, for the guidance and constant encouragement throughout the course of this study. His thanks are also due to the various Forest Officers of Punjab and Assam for the supply of leaves samples.

REFERENCES

Anonymous 1951. Soil survey manual. Soil survey staff, *U. S. Dept. Agri. Handbook*, No. 18, Govt. Printing Office, Washington, D. C.

Barshad, I. 1955. *Soil development : Chemistry of the soil*, edited by F. E. Bear, A.C.S. Monograph No. 126, Reinhold Publishing Corporation. 430, Park Avenue, New York.

Jain, N. K. 1960. Calcium relations of Sal. *J. Indian Bot. Soc.*, **39** : 357–372.

——— 1961. An investigation on the chemical requirements of Sal (unpublished).

Loomis, W. E. and Shull, C. A. 1937. *Methods in plant physiology*. McGraw Hill Book Co. Inc. New York.

Lutz, H. L. and Chandler, R. F. 1955. *Forest soils*. John Willey and Sons, New York.

Misra, R. and Puri, G. S. 1954. *Indian Manual of Plant Ecology*. The English Book Depot, Dehra Dun.

Pearsall, W. H. 1945. Leaf fall in Hartfordshire woodlands. Trans. Hartford, *Nat. His. Soc.*, **22** : 97–98.

Piper, C. S. 1947. *Soil and plant analysis*. Univ. of Adelaide, Adelaide.

Puri, G. S. 1952. The amount of foliar ash in Sal (*Shorea robusta*) trees of different classes in India. *J. Indian Bot. Soc.*, **31** : 82–88.

——— 1954. Land erosion—a problem in dynamic ecology. *Bull. 21 Nat. Geol. Soc. India*, 6–21.

Robinson, G. W., McLean, W. and Williams, R. 1929. The determination of organic carbon in soils. *Univ. College of North Wales Bougor.*

Russel, E. J. 1950. *Soil conditions and plant growth*. Longmans and Green Co., London.

Thompson, L. M. 1952. Soils and soil fertility. McGraw Hill Book Co., Inc. New York.

Upadhyaya, S. 1955. Soil formation under forest cover. *Bul. Bot. Soc. Saugor Uni., Sagar.* **7** : (1).

Waksman, S. A. 1938. The living soils. *Soil conservation*, **3** : 173–177.

Weaver, J. E. and Clements, F. E. 1938. *Plant Ecology*. McGraw Hill Book Co., Inc., New York.

Yoe, J. H. 1928. Photometric chemical analysis. **1** : 267.

REGIONAL IMBALANCE IN THE ARID PARTS OF RAJASTHAN

By

ANIL BARAN BOSE

Central Arid Zone Research Institute, Jodhpur

INTRODUCTION

In this paper an area having a normal annual rainfall of 20 inches or less has been taken as arid. This rather crude method had to be followed because of the absence of data on important variables like temperature, topography, type of soil, etc., which could form the basis for working out an aridity index. Accordingly, the author has included, Jaisalmer, Bikaner, Barmer, Jodhpur, Churu, Nagaur, Jalore, Jhunjhunu, Pali, Sirohi, and Sikar districts comprise in the arid parts of Rajasthan. Geographically, it is the region west of the Aravallis. District Ganganagar has been excluded even though it has a normal annual rainfall of less than 10 inches because it has a large part of irrigated land (6,90,066 acres 13·5 percent of the total area), and it was felt that its inclusion would bias the real picture of arid lands. Physically the arid parts present a vast expanse of sandy and barren tract interspersed with sand dunes and small hills. The most important river is the Luni and its tributaries none of these are perennial. The rainfall is erratic, scanty and mainly by the summer mansoon.

Population distribution :

In Rajasthan, 56·8 percent of the total area is arid, and supports 35·8 percent of the population of the state. Jaisalmer with the largest area (15,967 sq. miles) has the density of 6 persons/100 sq. miles while Jhunjhunu which is one-seventh of its area is more than forty-two times as densely populated. Since the nature and size of human habitations are conditioned largely by the availability of water and the ability of the region to support population, in the arid parts of Rajasthan where productivity is low, villages are of small size and are situated at long distances from one another. The percentage distribution of towns and villages classified by population shows that 61·9 percent have a population less than 500 ; 23·7 percent have a population between 500 and 999 ; 10·0 percent have a population between 1000 and 1999; 3 4 percent have a population between 2000 and 4999 ; 0·6 percent have a population between 5000 and 9999 ; and 0·4 percent have a population between 10,000 and 2,00,000. In Jaisalmer district where conditions of aridity are at their peak, 91·1 percent of the villages and towns have a population less than 500. There are only two cities with a population of more than 100,000 in the arid parts of Rajasthan, namely, Jodhpur (1,80,717) and Bikaner (1,17,113). Human habitations have sprung up wherever water is available and in the relatively drier districts of Jaisalmer and Bikaner, the population is scattered, so that there is both a nuclear settlement and *dhanis* (hamlets).

Growth of population :

The excess of births over deaths and the extent of migration determine the growth of population. The birth and death rates and migration are in turn

conditioned by a host of physical, economic social and even political factors. In the arid parts of Rajasthan the mean decennial growth rate of population has been fairly high as will be evident from Table 1.

TABLE 1

Mean decennial growth rate of papulation

Decade	Growth rate	
	Rajasthan	Arid parts
1901–10	6·6	7·1
1911–20	–6·8	–7 6
1921–30	13·2	14·6
1931–40	16·6	18·6
1941–50	13·9	15·2

Source : Based on data from Census of India, 1951, Rajasthan and Ajmer.

The table shows that the rate of population growth in the earlier decades was subject to violent fluctuations. The improvement of communication and medical facilities in later years has improved the situation. Surprisingly, the mean decennial growth rate is higher in the arid parts of Rajasthan than in the state as a whole. This is an alarming trend that needs to be curbed if there is to be no further deterioration in living standards since the capacity of the arid parts to support large populations is much more limited. It is interesting to note that there is little relationship between density in the different districts and the mean decennial growth rate therein. For instance, the coefficient of correlation between density in 1921, 1931, and 1941 and the mean decennial growth rate in the decades 1921–30, 1931–40, 1941–50 is –·055, –·0158 and +·146 respectively.

The future rate of population growth is likely to be still higher in the arid parts of Rajasthan. Statistics of birth rates and death rates are not available, but the broad-based age pyramid points to its youth. An idea about human fertility could be had from the fact that there are 61 children under five for 100 women in the age group 15–44 years. The early marriage system, together with the absence of any voluntary efforts to control the size of families lead to high birth rates while improving medical facilities and means of communication bring down the death rate resulting in increasing population.

Migration has played a very limited role in influencing population growth in the arid parts of Rajasthan. On account of the unproductive nature of the land, and the absence of large scale industries or mineral production, migration within the state has been restricted. Nevertheless some groups like the Banjaras and the cattle breeders are of nomadic or semi-nomadic types, and they move from one place to the other with their cattle. But this movement of population which is of a temporary nature and they return to their villages just before the rains.

Livelihood pattern :

Table 2 shows classification of livelihood pattern as given in the 1951 census report.

TABLE 2

Livelihood pattern of the general population

Class	Percentage
Agricultural classes	66·63
Non-agricultural classes	33·37
Production other than cultivation	9·69
Commmerce	7·91
Transport	1·08
Services and miscellaneous sources	14·69
	1000·00

Source : Based on data from Census of India 1951, Rajasthan and Ajmer.

The extent of dependency is high and is higher among the non-agricultural classes than among the agricultural classes.

Table 3 shows the industries and services in which the self-supporting persons are engaged. Economic activities other than those relating to the cultivation of land have been put in category of industries and services. These activities have been classified by the nature of the commodity produced or service performed.

TABLE 3

Percentage distribution of self-supporting persons of all industries and service by divisions

Division	Percentage
Primary industries not elsewhere specified	8·85
Mining and quarrying	0·84
Processing and manufacture–foodstuffs, textiles, leather and products thereof	12·36
Processing and manufacture–metals, chemicals and products thereof	1·92
Processing and manufacture–not elsewhere specified	7·68
Construction and utilities	4·71
Commerce	21·61
Transport, storage and communication	3·30
Health, education and public administration	9·92
Services not elsewhere specified	28·21

Source : Based on data from Census of India 1951, Rajasthan and Ajmer.

Table 4 shows the nature of land utilisation in the arid parts of Rajasthan. Only one percent of the area is sown more than once.

TABLE 4

Land utilisation (1956–57)

Use	Percentage
Forests	1·2
Not available for cultivation	16·5
Other uncultivated land excluding current fallow	25·9
Fallow land	22·2
Net area sown	34·2
Area sown more than once	1·0
Total cropped area	35·2

Source : Statistical Abstract of Rajasthan, 1958

Cottage industries are not developed and are followed in a limited way by the occupational castes. The products made are of an inferior quality and are meant to cater to local needs. For half the year the agriculturist is idle attending to odd household duties since most of the people belonging to the agricultural classes do not have a secondary means of livelihood. The tremendous overcrowding in agricultural areas will be clear from Table 5 which gives the number of persons depending on agricultural operations per square mile of cultivated land (agricultural density), the number of persons per square mile of cultivated area, and the number of acres of cultivated area per capita. The table shows the extreme form of imbalance in Jaisalmer where the general density is only 6 persons per square mile but the agricultural density is the highest being 156 times the general density. The number of acres of cultivated area per capita is also the least here, being only 0·2 acres. The coefficient of correlation between general density and agricultural density is –·074.

TABLE 5

Overcrowding on land in arid parts

District	General density (per sq. mile)	Agricultural density (per sq. mile)	Persons per sq. mile of cultivated area	Acres of cultivated area per capita
Jaisalmer	6	937	2634	0·2
Bikaner	39	65	123	5·2
Barmer	43	66	85	7·5
Jodhpur	73	145	237	2·7
Churur	80	95	132	4·8
Nagaur	111	174	230	2·8
Jalore	93	105	141	4·5
Jhunjhunu	255	225	319	2·0
Pali	139	273	472	1·4
Sirohi	142	931	1745	0·3
Sikar	230	230	339	1·9

Source : Census of India 1951, Rajasthan and Ajmer

The average size of holdings is large, but the productivity of land is low because of the uncertain rainfall and traditional agricultural practices. The average yield of bajra which is the staple food crop is between two and two and a half maunds per acre in a normal* year. Preliminary investigations made in this Institute have shown that there is subdivision and fragmentation of holdings. The farmer practices subsistence farming and rarely sells his produce ; rather, if there is a surplus he retains it to sustain him through the bad years. Mixed cropping and rotation of crops are followed, but little or no manuring is done. While no statistics are available about the productivity of land in successive generations, there is realisation that the productivity of land has gone down because of the over-use far beyond its capability which has been indulged in out of sheer necessity—the dependence of too many people on agriculture.

Besides the human population there is a tremendous overcrowding of livestock on the available land resources in the arid parts of Rajasthan, which further complicates the problems of population imbalance.

SUMMARY

There is regional imbalance in the arid parts of Rajasthan which comprise 56·8 percent of the total area of the state. The density of 74 peasons per square mile is high keeping in view the unproductive nature of the land. The high rate of population growth is portentous, the mean decennial growth rate during the three decades 1921–30, 1931–40, and 1941–50 being 14·6, 18·6, and 15·2 respectively. The growth of population is chiefly due to the excess of births over deaths. Birth rate is high, there being 61 children under five years for 100 women in the age group 15–44 years. There is tremendous dependence upon agriculture, almost two-thirds of the people belong to the agricultural classes. The percentage of non-earning dependents is abnormally high, being 48·15 percent among the agricultural classes and 63·79 percent among the non-agricultural classes. There is very high concentration of population on cultivated land, the agricultural density being as high as 937 persons per square mile in Jaisalmer. The size of holdings is large, the average size being 66·0 acres in Bikaner, but productivity of land is low and uncertain. The net area sown is 34·2 percent and only 1·0 percent is sown more than once. Thus the cultivator has to depend upon a single crop.

*There is a saying in the arid parts of Rajasthan that "in a hundred years there would be seven scarcity years, 27 good years, 63 half ripe years. and three such terrible famines that the mothers will not meet their sons".

ECOLOGICAL PROBLEMS IN THE TROPICS—EROSION IN RELATION TO VEGETATION COVER IN TWO AREAS OF VARANASI

By

R. S. AMBASHT

Department of Botany, Banaras Hindu University

The problem of soil erosion in India in relation to vegetation cover and soil properties has been dealt with by several workers, (Prasad 1942, Puri 1949, Ballal 1954, Mirchandani Guha and Vasudeviah 1958, Gupta 1958, Mukherjee 1958, Kibe 1958). The author has studied the problem of erosion from an ecological standpoint in two of the heavily eroded localities in the Varanasi area, the first being the ravines around Rajghat plateau to the North-East of the town and the second locality includes some portions of the University ghat areas along the Ganga river.

The climate of the area is of the monsoon type and is divisible in three clear seasons, *viz*. summer, rainy and winter.

Summer season is favourable for plant growth due to very hot and dry conditions accompanied with desiccating strong wind. The rainy seasons extends from late June to the middle of October. Average annual precipitation is 1016 mm. Nevertheless, during the course of this investigation from July 1957 to June 1958 the total precipitation was 1104 mm. and it was 1522 mm. during the following twelve months. The intensity of erosive forces is maximum in the rainy season as the rains are often in the form of heavy downpours. On 22nd July, 1957, the rainfall was 175 mm., on 16th September, 1958, it was 158 mm. and on 12th October, 1958, it was 146 mm. The rainy season due to high humidity, rainfall and temperature is very favourable for plant growth.

In winter season two sets of annual plants come up. The first set consists of those which appear on low-lying lands and river catchment areas. Dormancy of seeds in some of these species is broken by the decay of the seed coat under water-logging of the preceding rainy season. On recession of the floods these seeds germinate along with the other seeds such as of *Tamarix* sp. brought by the river current. The other set of winter annuals start their growth on uplands soon after the winter showers of December or January.

Erosion around Rajghat plateau is due to the heavy monsoon which has led to the development of numerous gullies. In heavy rainfalls abundant quantity of finer soil particles are selectively raised in splashes and laid on the surface and thereby reduce the permeability by clogging and sealing the pores in the surface layer of soil. Water runs off along the gradient and cuts small finger gullies which with the increasing gradient converge and form larger gullies. As these approach the river Varuna side they get further deepened and widened on account of increasing water pouring in from sides across the gullies. The fresh alluvium along river Ganga, because of high permeability of sandy soil, develops gullies to a less extent.

Vegetation :

The vegetation of the Rajghat area has been discussed by Misra (1944). The ravines of this area bear dominant tree growth of *Holoptelia integrifolia* and *Albizzia lebbek* with occasional plants of *Pongamia glabra*. But *Pongamia* becomes dominant

along with *Holoptelia* and *Albizzia* in shady regions of the ravines. Towards the confluence of Barna and Ganga on the plateau margins, trees of *Acacia leucophloea* are locally abundant, while other species, such as *Feronia elephantum Tamarindus indica* and *Ficus religiosa* are also found in this region. Towards the more humid regions along the river Barna *Ficus glomerata* is common while on sandy soils along the bank of Ganga *Acacia arabica* is frequent. In the second storey of this forest *Capparis sepiaria* is dominant with *Diospyros cordifolia* as co-dominant and *Clerodendron phlomidis, Abrus precatorius, Abutilon* sp. and *Lantana* sp. are occasional. On the sloping banks of the confluence of the two rivers very tall tussocks of *Saccharum munja* are common.

The ground flora in the summer season is very much reduced and *Cynodon dactylon* the only survivor of the pre-summer flora covers the plateau in small patches. Isolated colonies of *Ruellia prostrasta, Desmostachya bipinnata* and individuals of *Linaria ramosissima* are also found in the partly shaded portions of the ravines.

With the advent of rainy season in June–July the annuals make their appearance and the perennial weeds sprouts up quickly. The ground vegetation of the lightly eroding alluvium on the southern and western side at this time of the year is composed of the following species. (The notations used in this paper are : d = dominant, cd = co-dominant, a = abundant, f = frequent, o = occasional, r = rare, and v = the prefix 'very' and l = prefix 'locally').

Cynodon dactylon	d	Cassia tora	f
Crotalaria medicaginea ...	cd	Cassia occidentalis ...	o
Dichanthium annulatum ...	a	Achyranthus aspera ...	r
Cyperus rotundus	a	Euphorbia hirta... ...	r
Justicia simplex	f	Scoparia dulcis	vr

Most of the exposed and open plateau areas are covered with sods of *Cynodon dactolyn* mixed with *Crotalaria medicaginea* forming a dense mat of vegetation.

On the steeper gradients vegetation changes slightly and different species increase or decrease in density according to the intensity of erosion. Vegetational composition of the sloping regions of the ravines is follows :

Cynodon dactylon	va	Euphorbia thymifolia	f
Crotalaria medicaginea ...	va	Tridax procumbens ...	o
Abutilon sp.	la	Cyanotis axillaris ...	o
Vandellia crustacea... ...	vf	Urochloa reptans ...	o
Bonnaya brachiata	vf	Commelina benghalensis	o
Cassia tora	f	Achyranthes aspera ...	o
Cyperus rotundus	f	Aerua scandens ...	r
Phyllanthus niruri	f	Corchorus acutangularis	r
Evolvulus sp.	f	Dactylocteneum aegyptiacum	r
Euphorbia hirta	f	Kylinga triceps ...	r

On freshly exposed ravines due to land slips *Vernonia cinerea, Boerhaavia diffusa* and *Evolvulus* sp. appear first.

In the ravine beds, where erosion is sometimes accompanied with periodic inundation during the rainy season, the vegetation consists of the following species :

Cynodon dactylon	a	Oplimenus burmannii ...	f
Commellina benghalensis ...	vf	Freistrophe bicalyculata	f
Justicia simplex	vf	Achyranthes aspera ...	o
Cyanotis axillaris	f	Passiflora sp.	o
Setaria sp.	r	Rungia parviflora ...	o
Paspalidium flavidum ...	r		

During the winter season, a number of annuals come up and completely cover the flood plains around the plateau. The density of plants is higher at the confluence of rivers Barna and Ganga. This may be due to periodic inundation and silting erosion on the bed containing the diaspores of the preceding winter annuals. The ground vegetation is constituted by the following species growing in a dense mixed colony.

Xanthium strumarium ...	a	Mollugo hitra	f
Ranunculus sp.	a	Potentilla supina ...	f
Rumex dentatus	a	Polygonum plebejum ...	f
Solanum nigrum	la	Datura sp.	o
Argemone mexicana ...	vf	Oldenlandia sp. ...	o
Gnaphalium leuteo-album	vf	Lippia nodiflora ...	r
Gnaphalium pulvinatum ...	vf	Goldenia sp.	r
Croton sparciflorus ...	f	Alternanthera sessilis ...	r
Celsia coromandelina ...	f	Grangea maderaspatana	r

The fresh sandy alluvial deposits along the Ganga bank of the University ghat and Rajghat remain under cultivation in post monsoon period after the recession of floods. Due to rapid runoff in rainy season some gullies are formed. Isolated trees of *Acacia arabica* are very common throughout.

In summer season the vegetation consists of large colonies of *Alhagi camelorum* and *Chrozophora rottleri* with patches of *Solanum xanthocarpum*. On the commence. ment of rains the plants of *Chrozophora* and only the aerial parts of *Alhagi* die- Other species such as *Euphorbia hirta, Leucas aspera, Cleome viscosa, Cassia tora, Ricinus communis* seedlings, *Solanum xanthocarpum*, etc. appear in the area. In August and September when the river is in floods most of the annuals are inundated and perished. *Saccharum munja* occupying slightly higher regions survives during these months. The winter season annuals are very much similar to those described earlier for the beds of Rajghat ravines except for very dense growth of *Alhagi camelorum* regenerating from the underground parts (Ambasht, 1958).

Misra (1944) recognises the *Holoptelia–Albizzia–Cordia* association as the climax developing from the *Capparis–Diospyros* associes from eroded ground and *Saccharum–Alhagi* associes from new deposits of Ganga sides at Rajghat area. It has also been mentioned by the same author that the species forming stable characteristic communities have developed high degree of vegetative means of propagation and perennation (Misra, 1959).

Soil Conservation Values of local species :

The soil conservation capacities of certain species growing in both the localities have been experimentally studied to asses the role of these plants in checking erosion during the rainy season. Methods for assesing the soil binding values of plants have been developed by certain workers (Dittmer, 1938, Pavlychenko 1942, Campbel 1945, Carter and Law 1948), but on account of their limitations the author has developed a method for estimating quantitatively the conservation value of plants. A brief outline of the method is as follows :

Two parallel bunds of soil each 15 metres long and 1·5 metres broad were constructed in the Botanical Garden of the Banaras Hindu University. These bunds were sloping at an angle of 30° along their breadth into a common concrete channel. Each of the two bunds was devided into five equal blocks of 3 metres length and 1·5 metres breadth. The channel too was partitioned longitudinally and transversly in order to receive the runoffs from each block separately. Thus out of ten equal sized blocks nine were planted with different species and one was kept as control. After heavy rainfall or artificial showering the soil and water from sloping plots, both vegetated and bare, were collected in respective reservoirs. The muddy water was left undisturbed for a couple of days after which the overlying water was drained off and for the soil that settled down on the bottom was measured. Thus the quantity of soil eroded from plant covered and bare plots under identical conditions was obtained separately. The soil conservation value was then caclculated as the percentage of soil retained by the species which otherwise without its cover would have been washed away when subjected to an equal erosive force. The following formula was used to calculate the conservation value

$$Cv = 100 - \left(\frac{Swp}{Swo} \times 100 \right)$$

where Cv = conservation value, Swp and Swo are the quantity of soil washed from plant covered and bare plots respectively.

Data obtained from such experiments show that *Saccharum munja* is the most effective soil binder species of the locality. It is capable of conserving over 96% of the soil. Of this its underground parts alone account for 92% when the shoot is clipped close to the ground surface. On older alluvium the commonly grazed grass *Cynodon dactylon* is found to be capable of checking 95% of soil if grazing is effeetively checked. The conservation value for this grass decreases to about 75% when the shoot is closely clipped. In view of the fact that these two species are very well adapted to eroded localities and are effective soil binders, it is recommended that *Saccharum munja* and *Cynodon dactylon* be exploited for conservation purposes on new and old alluvial respectively.

ACKNOWLEDGEMENTS

The author is grateful to Prof. R. Misra, F. N. I., F. N. A. Sc., for guidance and encouragement during the course of this work and to Dr. S. K. Maitra for supplying the climatological data.

LITERATURE CITED

Ambasht, R. S. 1958. Studies on the underground parts of *Alhagi camelorum*, Fisch. *Proc. Nat. Acad. Sci.* (India) 28 (**B**) : 106–107.

Ballal, D. K. 1954. A preliminary investigation into some of the physical properties affecting erosion of Madhya Pradesh. *J. Ind. Soc. Soil Sci.*, **2** : 37–41.

Campbell, D. A. 1945. Soil conservation studies applied to farming in Hawke's Bay. Part I Investigations into runoff and soil loss. *New Zealand J. Sci. Technol.* Sec. A., **26** : 99–105.

Carter, J. F. and Law, A. G. 1948. The effect of clipping upon the vegetative development of some perennial grasses. *J. Amer. Soc. Agron.*, **40** : 1084–1091.

Dittmer, H. J. 1938. A quantitative study of the subterranean members of three field grasses. *Amer. J. Bot.*, **25** : 654–657.

Gupta, R. S. 1958. Report from 'Soil Conservation Research, Demonstration and Training Centre', Dehra Dun. *J. Soil and Water Conserv. in India.* **6** : 142–143.

Kibe, M. M. 1858. The role of vegetal cover in soil conservation. *Ibid.* **6** (4) : 160–166.

Mirchandani, P. M., Guha, D. P. and Vasudeviah, R. D. 1958. Soil loss studies in Deochanda Experimental Station. I. Effect of crop management practices. *Ibid.* **6**.

Misra, R. 1944. The vegetation of Rajghat ravines. *J. Ind. Bot. Soc.*, **23** : 113–121.

——— 1959. Environment, adaptation and plant distribution. *Pres. Add. Ind. Sci. Congr. (Bot).*

Mukherjee, J. N. 1958. Development work of soil and water conservation. *J. Soil and Water Conserv. in India.* **6** (2) : 59–66.

Pavlychenko, T. K. 1942. Root systems of certain forage crops in relation to management of Agricultural soils. *Publ. 1088. Canad. Nat. Res. Coun.* pp. 46. (not seen in original).

Prasad, J. 1942. Notes on some aspects of erosion control. *For. Res. Ins. Dehra Dun Ind. For.* Leaflet No. 27, pp. 17.

Puri, G. S. 1949. The problem of soil erosion and land slips in Hoshiarpur Siwaliks. *Ind. For.* **75** : 45–57.

THE PLACE OF BIOLOGICAL CONTROL IN FORESTRY RESEARCH IN INDIA

By

J. C. BASU CHOUDHURI

Forest Research Centre, Coimbatore

INTRODUCTION

To-day we stand at the threshold of the Third Five-Year Plan. The nation is actively engaged in the blue prints for inaugurating the campaign to usher in prosperiety. Entomologists who study humble insects can also share a modest part in the gigantic task of national planning. Numerous ubiquitous insects play vital roles in the economic development, growth and health of our country.

Before, I proceed to elaborate and substantiate my thesis—why and to what extent the study of parasites of insects are important and necessary in view of national planning and preserving our natural resources, an attempt may be made to appraise the relationship that exists between insects and mankind. We have to evaluate critically two salient considerations of topical interests. They are—

1. Contributions of forests in the developing economy of India.
2. Means and ways to devise effective, more or less permanent and inexpensive control methods of forest insect-pests which threaten to deplete our forest resources.

THE VALUE OF FORESTS

It hardly needs any emphasis to state that the forest resources of a country are national assets ; they constitute an important source of national wealth. The forest also act as the faithful and friendly "sentry" to prevent drought, soil-erosion, maintaining the water-table of soil, improving the natural landscapes, providing shelters to wild life etc. The Chief of Forest Service of U. S. A. Dr. R. E. McArdle has stated (1958)—"Tommorow the Nation's need for timber will strikingly greater than to-day or any time in the past." If the statement is applicable to a highly industrialized country like United States then surely, it holds brighter prospects for a rapidly-developing country like ours.

PROBLEMS OF INSECT DEPRECIATIONS AND CONTROL MEASURES

In general, insects cause unbelievable amount of damage to all kinds of human activities. One has to admit that the menace of insects to our standing crops, stored- grain product, stores and forests is no mere bogey, but is one of the alarming phenomenon of our present day civilization and trade. The distinguished American entomologist Dr. L. O. Howard has said—

In recent years we have seen in India and experienced damages of high order which are caused by insects—destroying our much needed food (standing crops and stored grains) and forest resources alike (Table 1). To add to our miseries, insects act as vector of virulent microbial diseases which take heavy toll of human lives and live stocks. When the statements of vital statistics of enormous lossess sustained by insects, are prepared, we are bewildered. The first question which

1. It requires longer duration of observational period to collect relevant data on parasite before releasing them in fields and to assess mortality results of insect-pests against which the parasites are released.
2. The phenomenon of hyperparasitism often reduces the desired effect primary insect parasite as a controlling agent of serious insect pests.

These limitations are inevitable because, the method of biological control chiefly, involves following procedures :

1. Thorough survey and selection of specific parasite.
2. Mass propagation and release experiments.
3. Encouragement and proper colonization of native and introduced parasties.
4. Improvement in environmental resistance of the pest by modification of plant community to promote and accelerate the process of natural control.

BIOLOGICAL CONTROL OF INSECT PESTS AND NATIONAL PLANNING

The concept of biological control has very wide applications. Hence, I deliberately propose to refer briefly, to its applications (utilizing virus, bacterial and fungal diseases and invertebrate parasites of insects only in the restricted field of forest entomology.

In order to evolve an effeetive, inexpensive and permanent measure to check the sporadic epidemics of destructive forest insect pests it is necessary that the biological control methods should be encouraged in conjunction with silvicultural and cultural practices. Here, it is apt to emphasize that to achieve this objective in forestry and interrelated forest industries, it is very essential to organise well-integrated and sustained research programmes on entomo-parasitological studies with special reference to insect pathology. The science of insect-pathology is relatively a new discipline of biology. It is being rapidly developed in U. S. A., and Canada ; it has a bright future in the field of applied entomology. Unfortunately, no studies in this direction have been either contemplated or initiated in India particularly on forest insect pests. Precisely, at this point entomologists with vision and foresight can focus the immediate need and importance of parasitological cum pathological studies of insects, to control damage caused to our forests by them. Such studies have a rightful place in the national planning of India and promise to contribute results of significant importance.

The drawbacks of the method as pointed out earlier are surmountable. The sponsoring agencies for advance scientific studies in the country like I. C. A. R., C. S. I. R., and the Union Ministry of Food and Agriculture in collaboration with their State counter parts should be willing to realise the seriousness of studies suggested above, in terms of the available natural resources of the nation which regularly experience collosal depreciations caused by insects. This wastage puts a heavy drainage on our national wealth and foreign exchange reserve. To meet this grave situation intelligently, the authorities must be prepared to provide financial and technical facilities to draw long-term, extensive and intergrated research programmes on insect parasitological and pathological investigations related to insects which are responsible for causing severe damages to our agricultural and forestry resources.

BIOLOGICAL CONTROL—A NEW TOOL AGAINST FOREST INSECTS

To elucidate some outstanding illustrations how parasites of insects have helped in protecting forests and timber resources from ravages of insect outbreaks; the following examples may be studied.

(a) Insect pests of teak and their control in India.

Teak (*Tectona grandis*) is one of the most highly prized timbers of the world. It is playing a significant role in the developing economy of the Country—with the advent of newly found wood-base industries *e.g.*, shipbuilding, ply-wood and veneer processing and numerous constructional projects.

Teak is highly susceptible to defoliation by two lepidepterous caterpillars—particularly,—defoliator (*Hyblae purea*) and skeletioniser (*Hapalia macharalis*). These two species have a sequence of 13–15 generations a year in South India and 8–10 generations in North Indian teak stands. The effects of defoliation are—dying back of leading shoots, forking and formation of epicormic branches. Instances are also recorded specially where saplings after repeated defoliations met with total mortality. However, complete defoliation does not cause total mortality to mature and healthy teak trees. In other words, defoliation is chiefly responsible for loss in increment and thus, incur a recurring financial loss of high magnitude.

The Forest Research Institute at Dehra Dun has conducted several studies on the biology of teak defoliators and from time to time has recommended methods suitable to combat these pests. Beeson (1934 p. 680) has recorded 22 species of insect parasites on *puera* and 43 species on *macharalis*, out of which five are common to both host species. Bhatia (1948) have observed from the total list of parasites 15 are monophagous and 38 species as polyphagous. Chatterjee (1951) has given a list of introduced insect parasites of teak defoliators from Burma during 1937–38. Biological control is working effectively in many teak plantations during past 30 years and encouraging resuts are forthcoming. However, the final assessment has not been attempted so far on trans-India basis.

Beeson (1934) has stated : "when all the agencies of biological control are working effectively defoliation will be restricted to a light grade of skeletonisation, perforation of ragging, with occasional foci of high population density that do not spread but disappear in one or two weeks. Wide spread epidemics will not occur. It will need extremely abnormal weather conditions to upset the balance of control and cause an epidemic."

(b) Sisham and Mulberry defoliators in Punjab :

The Sisham-mulberry plantations of Changa-Manga in Punjab were severely defoliated by the defoliator, *Margorina pyolis.*

The hymenopterous parasite (*Cedria paradoxa*) from teak defoliator in Dehra Dun was found to be able to parasitize the caterpillars of mulberry defoliators. This parasite was not found in plantations in Punjab. Therefore, large numbers of these parasites were reared at Dehra Dun insectary. Over 15,000 individuals were taken to Changa Manga plantations and released against the mulberry defoliators. The results were highly suecessful (Gardner, 1937.)

(c) Gypsy moth—an introduced pest in U. S. A. :

The gypsy moth (*Porthetria dispar*) is a leaf eating insect native to Europe and Japan. It is a common pest of forests, shade trees and orchards in its natural habitats ; it has never acquired the status of a destructive pest in Europe or Japan on account of heavy parasitization by native insect parasites. The moth was accidently introduced into Medford, Mass., (U. S. A.) from France by an amateur French entomologist in 1869. In the "new home", it spread through most of New England area within very short period. This large-scale dispersal was due to the fact that no native and specific parasites of the species were present in the country which could check its phenomenal population increase. Moreover, the food supply was also abundant.

In an early epidemic outbreak in last century few trees were left untouched in North America. Defoliation caused by gypsy moth has retarded growth and killed trees specially forest trees over extensive areas. Gradually it has acquired the status of serious pests of hardwood forests and orchards alike. Concerted efforts by the Congress (U. S. A.) through introduction of legislations and intensified entomological investigations generously financed since 1906—till to date have helped to check wide-scale damages caused by this pest.

The Gypsy Moth Laboratory at Melrose Highlands, Mass., devoted much efforts in introducing natural enemies of the pest from its native haunts. During the period of 30 years more than 60 species were successfully introduced in U. S. A. to control the wide spread increase of gypsy moth ; 16 or more species became permanently established and about 8 species have become definitely useful preventing outbreaks of gypsy moth (Graham, 1952).

(*d*) *Nun moth—a serious pest in European forests* :

During 1870–1920 spruce and pine forests of Central Europe have seen several devastating and periodic epidemics of nun moth (*Lymantaria monocha*) (Graham, 1952). These outbreaks sustained serious financial losses to timber industries of Germany and neighbouring countries. Extensive research projects were planned and carried out to study the nun-moth in all its detail. It was found that nun-moth suffers from a lethal virus disease called "Wipfelkrankheit". Since the discovery of this virosis in 1889 the virus along with other insect parasites have been successfully utilized to control nun moths which were responsible for complete depletion of forests in Central Europe more than one hundred year. Now, the pest is under check and localized epidemics of short durations occur which are suppressed readily.

(*e*) *Some other important illustrations* :

(*i*) The European larch saw fly (*Pristiphora erichsonii*) has created havocs to Canadian forests. This destructive pest is now controlled by introducing insect parasite from England.

(*ii*) During 1930–38, the European spruce saw fly (*Diprion* (*Gilpina*) *hercyniae*) threatened to destroy the spruce forests of Eastern Canada and parts of New England (U. S. A.). Accidentally with the importation of insect parasites of the pest from Europe, a virus was also introduced unnoticed. This introduced virus attacked with great virulence the Europe an spruce saw fly, with a result that a new virus disease appeared. The disease was thoroughly studied by Balch and Bird (1944) and successfully used to control the outbreaks of European Spruce saw fly (A. B. Bird, 1937).

(*iii*) Recently in U. S. A., effective and successful control of European pine saw fly (*Neodiprion fulviceps*) has been achieved by ground and aerial spraying the infested forests with an insect virus. The virus spreads a deadly virosis in European pine saw fly. The spraying operations are yielding useful and valuable results (F. T. Bird, 1953.)

(*iv*) The results and achievements of biological control of forest insect pests by utilizing parasites of insects in the past are so encouraging that both in U. S. A. and Canada well organised and planned programmes (about 16 projects) are being assiduously investigated to preserve their forests and timber resources against the destructive insect pests. The timber resources of the North American countries have played a key role in the past, and now, also is

responsible for accelerating the pace of industrial advancements. In this direction, useful results are judged to have produced against the following species of forests insect pests (Prebble, 1960).

(*a*) The satin moth, the European spruce saw fly, the European pine saw fly and the larch case bearer (in U. S. A. and Canada).

(*b*) The gypsy moth, the oriental moth, the elm leaf beetle and the European elm scale (in U. S. A.).

(*c*) The lecanium scale and the holly leaf minor (in Canada).

(*v*) *White grubs and caterpillars of forest insect pests in Japan* :

In Japan, the utilization of bacterial and fungi for the control of white grubs (*Anomala rufocuprea*) and catterpillars (*Dendrolimus spectabilis* and *Liparis fumida*) pests on forests trees has been studied by pathologists and entomologists since 1925. Some recent experiments have indicated the possible use of fungi (Genus : *Spicaria*) against white grubs. However, these investigations are still in the experimental stage (Watanabe, 1956).

(*vi*) *Control of Eucalyptus weevil in South Africa* :

An important and spectacular success in South Africa has been achieved to control the eucalyptus weevil, *Gonipterus scutellatus* by the mymarid parasite *Anaphoidea niteus* (Thompson, 1956).

TASK FOR FUTURE

I have tried in the course of this article to touch on insect problem which threaten to destroy our forest resources. The distinguished Forest Entomologist of U. K., Professor J. W. Munro has stated (1929) : "Insects may not only cause delay or difficulty in marketing, but they may even govern the market itself. In Central Europe when periodic massed outbreaks of Nun moth occur in spruce and pine forests, so much timber is "Killed" that it gluts the market and prices fall with rush".

The potential demand for timber and wood products in India is expected to rise along with anticipated growth of populations and economic activity. To achieve our target forest outputs by way of implementing large scale afforestation schemes, we must also pay serious attention to preserve our present standing forests against wanton destructions by insects. Insects in general, are exposed to attack of various kinds of parasites including micro-organisms. Research with viruses and bacterial diseases in U. S. A., Canada and Sweden has produced hope that these may soon be used directly against outbreaks of forest insects. The methods employed to control epidemics of forest insect pests in highly industrialized countries, as illustrated above have provided strong indications that the biological control will be a new and formidable tool against forest insects. In India, we must look forward to intensified research programmes to acquire more knowledge about the ecology of insects and their parasites. To accomplish this task, concerted efforts may be organised to develop long term comprehensive studies on insect ecology of forestry and agriculture importance with special reference to parasitological and pathological investigations. Such applied studies will play vital role in the projected national planning to control the damage and wastage caused to our valuable and limited natural resources.

SUMMARY

The concept of biological control has very wide applications. Hence, I deliberately propose to refer briefly to its applications (utilising the principles of virosis, bacterial and fungal diseases) and parasitism by invertebrate animals only in the restricted field of forest entomology. The method offers special opportunities in forest protection. The advantages are outlined. The results of long term experiments conducted in this direction in highly industrialized western countries, specially, in the U. S. A., Canada, Germany and Sweden, where forests are vital sources of national wealth, it has been a consensus opinion of the expert forest entomologists that the method of biological control is a new and formidable tool against forest insects.

To elucidate how the parasites of insects have helped in protecting forest and timber resources from the ravages of insects damages some outstanding examples are referred from the world literature.

These examples emphasise that in India we must look forward to intensified research programmes to acquire more knowledge about the ecology of insects and their parasites. To accomplish the task, concerted efforts should be organised to develop long-term comprehensive studies on ecology of insects of forestry and agricultural importance with special reference to parasitological and pathological studies. Such applied studies will play significant role in the projected national planning to control the damage and wastage caused to our valuable and limited natural resources year after year.

REFERENCES

Balch, R. E. and Bird, F. T. 1944. Disease of the European spruce sawfly and its place in natural control. *Sci. Agric.*, **25** : 65–80.

Beeson, C. F. C. 1934. The biological control of Teak defoliators. *Ind. Forester*, LX (**10**) : 672–683.

Beeson, C. F. C. 1941. The Ecology and Control of the Forest Insects of India and Neighbouring Countries, pp. *i-ii*. 1–1007.

Bhatia. B. M. 1948. On the plant–defoliator–complex (In the biological control of Teak defoliators). *Ind. For. Rec. Entom. N. S.*, **7** (6) : 193-211.

Bird, A. B., 1937. Biological Control of the Spruce sawfly. *Pulp Paper Mag Can.*, March, 1937.

Bird, F. T. 1953. The use of virus disease in the biological control of the European pine sawfly, *Neodiprion sertifer* (Geoffr). *Can. Ent.*, LXXXV (**12**) : 437–446.

Chatterjee, P. N. 1951. The A B C of the problem of biological control of Teak defoliators. *Mad. For. Coll. Mag.*, **27** : 127–132.

Gardner, J. C. M. 1937. Biological Control of Forest Insects. *Ind. Forester*, LXIII (**11**) : 769–772.

Graham, S. A. 1952. Forest Entomology, *i-xii* 1–351.

McArdle, R. E. 1958. (In–Timber Resources for America's Future), Forest Service, U. S. D. A., *Report No.* **14** : *i-ix* 1–713.

Munro, J. W. 1929. Insects and Industry, pp. 1–80.

Prebble, M. L. 1960. Biological control in forest entomology *Bull Ent. Soc. Amer.*, **6** (1) : 6–8.

Thompson, W. R. 1958. Biological control in some Commonwealth countries. *Proc. X Int. Ent. Cong. Montreal*, **4** : 479-482 : 1956 (1958).

Watanabe, C. 1958. Review of biological control of insect pests in Japan, *Proc. X Int. Ent. Cong., Montreal*, **4** : 515–517 : 1956 (1958).

THE PROBLEM OF TEMPERATURE AND HUMIDITY IN RELATION TO TROPICAL INSECTS

By

U. S. SRIVASTAVA

Zoological Department, Allahabad University

The superabundance of insects in the tropics is a problem to the economic biologist. Most tropical insects are sternothermic and live in environments the temperature of which does not go below 15°C ; some are eurythermic. They show a very high thermal death point, and have morphological and behavioral characteristics to avoid excessive heating *e.g.* matallic or dull colours of the body, rounded shape, and exploitation of favourable microclimates. Inspite of being poikilothermic, they can lower their body temperature below that of the environment by evaporation at the surface. In this matter, size is an important factor. Evaporation depends upon size of body, length of exposure and humidity of air, besides temperature. Another notable feature of tropical insects is their multivoltine nature. Closely related species or the same species found in different parts of the world show this feature clearly. Absence of hibernation, winter diapause and related phenomenon occurring with insects of colder climates causes nearly continuous cycles of development in the tropics ; longer and brighter days in winters impart radiant solar energy which is apparently used for metabolism and growth ; and the rate of metabolism, following Van't Hoff's law, increases with temperature so that development of each stage and of the entire life history is proportionate to temperature within the effective range, but the law of summation of heat is not precisely applicable. It is also established that variable temperautre, in nature, as contrasted with the constant temperature of laboratory conditions is more condusive to development and to live generally. The occurrence of several crops in the year is extremely useful and a majority of insects is not specific in food habit. The influence of humidity is inseperable from that of temperature and is very variable. The chief effects is through controlling evaporation. Broadly speaking high temperature is most injurious when combined with high humidity for large to moderate sized insects, but high humidity appears useful for small insects. However, individual species must be studied to determine the exact reactions. Their knowledge can be used for control, firstly by forecasting time of emergence, attack, etc. ; secondly, while temperature cannot be controlled, the factor of humidity can be used for creating adverse conditions for existence and development.

ROLE OF SILVICULTURE IN AFFORESTATION WITH SPECIAL REFERENCE TO AFFORESTATION WORKS OF MAHARASHTRA STATE

By

D. V. KHISTY

Conservator of Forests, Poona

By afforestation is generally understood, conversion of land which may be bare or devoid of tree growth into forest. Therefore, Afforestation essentially constitutes an ecological problem, which needs a detailed study of various factors of locality, the biotic factors that have contributed to the denudation of the land, the actual ecological status of the land and its potentialities for development. Naturally, it is necessary to device the silvicultural practices and techniques most suited to each type of area, having a particular set of conditions.

Need for Afforestation in Maharashtra State :

The total land area of Maharashtra State is 1,18,721 sq. miles, of which the forest area is 26,000,04 sq. miles. The forest area therefore forms 22·4% of the total land area of the State, as against the optimum of 33⅓% required to build up the rural economy of the country. These forests are also unevenly distributed in scattered bits, generally away from centres of populations and industries. Further, the forests are also not uniformly stocked with useful species but are too open and sometimes bare. Therefore, the present area of the forests is too megre to satisfy the needs of the growing population which at present stands at 3,20,03,086 or 3·20 crores and indicates the need for Afforestation.

The heavy fellings both in Government forests as well as in Private forests for meeting the enormous demand of timber, firewood and charcoal, during the IInd World War, the extensive deforestation of wooded areas for bringing them under plough, under the "Grow More Food Campaign", the indiscriminate cutting of the ex-Jahagiri and Inam Forests, just prior to the passing of the Jahagir Abolition Act, have been mainly responsible for the general deterioration in the condition of our forests. To add to this, the biotic factors consisting of illicit fellings, and hacking by man, uncontrolled grazing and fires have further added to the denudation and destruction of the forests, especially in the dry zone belt. The denuded hill slopes and the barren countryside that are often encountered in our State, point out the evils of accelerated soil erosion and deforestation and the immediate necessity of undertaking large scale Afforestations Schemes in the State.

The main Afforestation problem of the State may be devided into the following three categories :

(*i*) Afforestation of the open lateritic areas of the West Coast.

(*ii*) Afforestation of the coastal sand belt.

(*iii*) Afforestation in the Dry Zone Region.

Of the three categories mentioned above, Afforestation in the Dry Zone Region poses the most formidable problem both on account of the large areas required to be tackled and the inhospitable conditions of soil, moisture and adverse biotic factors.

(*i*) *Afforestation of the open lateritic areas of the Ratnagiri District* :

The rainfall in this tract is about 80" to 120". However, due to adverse biotic factors consisting of heavy grazing, illicit cutting and hacking, fire and shifting cultivation, the areas have been completely denuded of tree growth and are under various stages of sheet and gully erosion. Most of the areas comprise marginal lands belonging to private individuals. A scheme for Soil Conservation and Afforestation in Ratnagiri District is already under execution under IInd Five Year Plan and such areas are being acquired from Malkidars and are being afforested.

The species tried here is *Anacardium occidentale* which is planted in 1 foot cube pits. The surface soil is capped with hard laterite which on digging, gets softer underneath. *Anacardium occidentale* is generally raised by direct sowing supplemented by polythene bag plants. The species has been raised with fair amount of success and is expected to yield the important dollar earning cashewnut in 3 to 4 years time. The planting of cashew, in eroded lateritic soils appears to be very promising, in improving the rural economy of Ratnagiri District.

(*ii*) *Afforestation of the Coastal Sand Belt* :

There is a belt of about 450 miles along the west coast. The erosion of sand caused by sea-wind, affects the fertility of the agricultural lands in the interior, due to deposition of sand. Stabilisation of coastal sand is necessary and at present this is achieved through raising of *Casuarina* plantation in the small portion of land in charge of Forest Department. Since coastal erosion is an important problem to be tackled, it is necessary to carry out thorough survey and recommend to Government to hand over the Forest Department, suitable strip of sandy area for undertaking large scale afforestation, by planting belts of *Casuarina.*

(*iii*) *Afforestation of Dry Zone Region* :

The rainfall in this region varies from about 10" to 30". The climax type of vegetation here is the Dry Tropical Forests—Tropical thorn. The principal species are *Acacia catechu, Acacia lencophloca, Anogaissus latifola, Butea frondosa, Ziziphus jujuba, Bauhinea racemosa* and shrubs like *Lantana camara, Rhus mysorensis, Gymnosporia montana,* etc. However, due to adverse biotic factors such as uncontrolled grazing, illicit cutting and hacking and fire, very little tree growth is left, which is also malformed and unsound. As a result, soil erosion has set in, exposing the subsoil and outcrops of rocks in several places.

Afforestation Technique :

Drawing inspiration from Gradoni System of continuous contour trenching and afforestation, experimental work was started in 1939 in Khed Range of Poona Division which was further extended to Chimangaon and Sangola in Satara Division. However, it was only after Independence that the pressing need for the expansion and development of this activity was realised and ambitious programmes of large scale afforestation came to be included in the Five Year Plan Schemes.

With the experience gained, the technique was modified to suit the areas individually and aiming at reduction in the cost of afforestation.

(A) Soil and Moisture Conservation Measures :

(*i*) In flatter and gently sloping areas, contour furrows are prepared at an interval of 18' to 20'. The method adopted is to plough a strip about 4' in width and form a bund having a base of 18" to 24" and height 9" to 12" with cross-section of an isoscales triangle.

(*ii*) On hill slopes, a system of staggered contour trenches is developed. This individual trenches are $12' \times 2' \times 1'$ along the contour and staggered with those in the next line which is usually 33' apart along the slope. After digging the trench of the above dimension, soft and superficial earth excavated from it is kept on one side for refilling the trench, while murum and stones are stacked on the lower side of the trench to serve as base. The hill slope is then scraped and excavated superficial earth mixed with soft earth obtained from the trench is filled up to form surface with 1 : 3 inward slope. The trench is then toed with boulders.

(*iii*) Generally where it is rocky and soil is limited to few pockets, pits $1' \times 1' \times 1'$ are dug. In some places trench type of pits $2' \times 2' \times 1\frac{1}{2}'$ are dug and toed with stones to hold the soil filled with an inward slope of 1 : 3. The contour trenches are also combined with pits, the latter being dug in the intervening space between successive contour trench lines, at an espacement of $12' \times 12'$.

(*iv*) Gully plugging and checkdaming of small gullies and nallas is done by dry rubble or brushwood, available in the locality. The interval in between the plugs varies, according to the slope and width of the gully. The height is generally kept at one foot.

(B) Afforestation :

The Afforestation Schemes generally recommend planting of the following 34 species :

(1) Acacia arabica
(2) Acacia catechu,
(3) Azadiracta indica,
(4) Acacia leucophloea,
(5) Ziziphus jujuba,
(6) Tamarindus indica,
(7) Prosopis spicigera,
(8) Prosopis juliflora,
(9) Acacia modesta,
(10) Pongamia glabra,
(11) Albizzia amara,
(12) Cassia siamea,
(13) Albizzia lebbek,
(14) Dalbergia sissoo,
(15) Swietenia mehogani,
(16) Chloroxylon swietenia,
(17) Sapindus trifoliatus,
(18) Gmelina arborea,
(19) Melia azadirach,
(20) Phyllanthus emblica,
(21) Anona squamosa,
(22) Pterocarpus marsupium,
(23) Holoptelic integrifolia,
(24) Aegle marmelos,
(25) Mangifera indica,
(26) Bassia latifolia,
(27) Hardwickia binata,
(28) Eucalyptus species,
(29) Santalum album,
(30) Diaspyros montana,
(31) Buchanania latifolia,
(32) Tectona grandis,
(33) Buchananis latifolia,
(34) Eugenia janbolana.

Generally direct sowing of seed is adopted as the common method of Afforestation. However teak and sissoo stumps are also put in. If no favourable rains are received after sowing, re-sowing needs to be done. The casualities are also replaced to a small extent by polythene bag raised seedlings. Generally three weedings are required to be done in the first years—two in the second and one one in the third year. Along with the last weeding, soil working is also done. Cleaning is prescribed in the fifth year.

Of the 34 species recommended for planting in the Afforestation Schemes, following have done well in a majority of the cases :

(1) Dalbergia sissoo,
(2) Albizzia lebbek,
(3) Albizzia amara,
(4) Acacia catechu,
(5) Prosopis juliflora,
(6) Acacia arabica,
(7) Azadiracta indica,
(8) Pongamia glabra,
(9) Santalum album,
(10) Bassia latifolia,
(11) Melia azadirach,
(12) Cassia siamea.

Teak is generally tried where the soil is sandy loam and deep, with rainfall of about 25" to 30". Of all the species tried, stum-planting of *Dalbergia sissoo* has yielded very successful results. *Dalbergia sissoo* appears to be the most important all-round valuable species which should find increasing use in all Afforestation Areas. Dibbling of sandalwood has given good results in parts of Barshi and Ahmednagar Afforestation Schemes. *Gliricidia maculata*, which was tried on a small scale has also given good results at Barshi. Ficus stakes have also been put in where the soil is hard. *Cassia siamea* and *Melia azadirach* have come up very well. However, the latter is found to die-back in some places after a period of 2 to 3 years. *Dendrocalamus strictus* is also tried on a small scale for planting in checkdams, where soil gets deposited.

It is observed that *Acacia arabica* is being attacked by the collar borer, especially in Ahmednagar Afforestation Area resulting in heavy mortality. So also, in the case of *Azadiracta indica*, the shoot dies down resulting in forking. It is under investigation whether the damage is due to attack of shoot borer or by fungus.

Silvicultural considerations involved in Afforestation Operations:

Soils :

Usually in all afforestation sites, the soils are extremely poor, degraded and shallow. Therefore in order to make the soil receptive to the growth, it is essential to adopt soil ameliorative techniques such as contour trenching, pitting or formation of Varalies on raised bunds at suitable places. The object is to have a fairly deep column of worked up soil for the roots to penetrate easily and establish themselves. The above measures also help in soil conservation and reducing accelerated erosion. Wherever the soil is too shallow or rocky, it is better to exclude such patches from planting operations.

The soils in the dry seasons are prone to salinity, as the evaporation is more than percolation, the soils in the sub soil rise to the surface due to the capillary action.

High concentration of salts in the soil leads to a condition of physiological drought and only hardy species which can withstand salinity need to be tried in such soils.

Before undertaking any afforestation work, it is essential to carry out a thorough inspection and survey of the area and a detailed map prepared so as to facilitate proper selection of suitable species.

Therefore for the success of any Afforestation Scheme, it is absolutely essental to adopt all the available moisture conservation measures so as to take the best advantage of the meagre rainfall for the growth of plants.

In this respect the contour trenches, pits and varalies also help in arresting the surface runoff and ensure better seepage of rainwater. From the point of view of moisture conservation, contour trenches generally are most effective.

The moisture conservation capacity of the contour trenches could be further improved without any increase in the cost of operation provided the soil from the trenches is piled up in the form of a mound on the down-hill side, co-extensive with the trench, on the ground previously pick-axed. Such trenches are already in vogue in Madras and Orissa and it is proposed to try them in about 25% of the Afforestation area from next year for conducting comparative study of the trenching system.

The importance of soil working and mulching in helping moisture conservation by breaking the capillaries can never be over-emphasised, especially in the dry tract. Special attention needs to be paid to this item to ensure success of Afforestation Schemes.

Gully plugging and check damming is done in the first year which also helps in a large measure in improving the hydrological ragime of the area. They also help in arresting soil erosion and the soil that is deposited behind the gully plugs and check dams forms a useful bed for raising plants from the second year.

At present, there is no uniformity in the size or interval of gully plugs prepared in various afforestation areas. It is therefore necessary to undertake a comparative study about the efficacy of various methods of gully plugging with different vertical intervals in different types of soils.

Closure and Fire-protection :

The success of rehabilitation and afforestation of the lands, denuded on account of biotic factors, depends essentially on the effective closure and strict fire-protection of the area concerned. These, in turn, will improve the soil and moisture conditions of the area and start primary succession to set in. The barren area will get gradually invaded with grasses and shrubs in the first instance and as the conditions become more and more mesophytic, it leads to secondary succession resulting in the establishment of tree species. However, left to Nature a number of years will be required for such ecological progression. The various soil and moisture conservation measures described above, coupled with Afforestation, only help nature in trying to attain the climax type of vegetation within as short a period as possible.

At present, the afforestation areas are fenced with livehedge of Agave in the first year. This livehedge fencing is not very effective since it takes several years to establish itself and become really an effective fencing. Besides, the fencing is also costly due to high initial cost of collection and transport of Agave suckers. It is therefore under consideration to adopt the cattleproof ditch or trench fencing, at present adopted in West Bengal, Uttar Pradesh and Madras with suitable modifications.

Fire-protection is ensured by allowing cutting of grass free by the local villagers, which also helps in winning the goodwill and co-operation of the people and reducing fire hazard due to incindiarism. Besides, the fire protection measures of cleaning and burning fire lines round the afforestation areas, coupled with fire resisting capacity of Agave fence are quite adequate in ensuring effective fire protection in the afforestation areas.

Choice of Species :

The problem of rehabilitation and afforestation of the lands, denuded on account of biotic factors, is essentially an ecological one. The ultimate aim should be to bring the areas under a reasonably stable formation with the principal indigenous species of value, within the shortest period as possible. However, to begin

with, afforestation should be carried out with a mixture of pioneer species which are quick growing in the initial stages and are required to serve as soil cover, though they may not yield any produce of value, till the crop of the principal species is established.

In all afforestation works, correct choice of species ensures the ultimate success of the undertaking. It is generally believed that local species invariably succeed. The vestiges of the species lying in the same area which will be evidently hardy, and which perhaps formed part of the natural stable formation in the locality, will give an indication of the suitable species to be tried in the afforestation areas. In actual execution of afforestation schemes, there is a general tendency to concentrate only on economic species, irrespective of their suitability or otherwise to the soil conditions. However, in badly eroded areas having shallow soils and where the primary object is soil conservation, the green cover of even uneconomic species, bushes and grasses, should be an asset, if they can recloth the area successfully in the shortest possible period. Though *Cassia siamea* and *Melia azadirach* have been included in the list of 34 species recommended for planting in afforestation areas, there has been a general feeling in recent years that these should not be tried because *Cassia siamea* is economically a useless species and *Melia azadirach* is comparatively short-lived. However, *Cassia siamea* is a leguminous tree which improves the soil through rootnodules, easy decomposition of leaflitter and side-shade. *Melia azadirach* also being a fast-grown species, is also a useful soilcover. Though it may not be desirable to plant these two species on a large scale, just to show the initial success of afforestation schemes, it is worthwhile planting them well distributed over about 10% of the area as a useful pioneer species and soil cover. To the list of fast growing leguminous plants, may be added *Gliricidia maculata* which supplies both firewood and valuable leaf-manure.

Selection of seeds for afforestation has to be done very carefully. The seeds should invariably be obtained from areas having similar conditions of soil and climate as in the afforestation area. *Acacia catechu* grows under different climatic and soil conditions and the above principle should be adopted while selecting the seed. Seed of *Prosopis juliflora* should always be selected from plants having erect habit so that the seedings raised the thereform should not have any creeping habit.

It is an accepted silvicultural principle that more adverse a locality, the purer the natural crop tends to be. It is therefore necessary to avoid intricate mixtures and to limit the number of species to a few, which have been found most suitable by experience in various afforestation works.

Generally the following species may be considered suitable for the type of soil mentioned against it :

Sandy soils : Dalbergia sissoo, pongamia glabra, Hardwickia binata.

Saline soils : Acacia arabica, Azadiracta indica, Acacia catechu, Prosopis juliflora.

Clayey soils : Acacia arabica, Azadiracta indica, Albizzia lebbek.

It is desirable to raise *Prosopis juliflora* only in saline or poorer soils where more valuable species cannot come in. In rocky and shallow soils, *Anona squamosa* does well. *Tecoma undulata* and *Dodonea viscosa* are also hardy and may be tried in such area with a view to add to the greenary and beauty of the vegetation even in summer.

Other species which are proposed to be tried are *Eucalyptus hybrid* and *Eucalyptus camaldulensis* which are fast growing species.

Majority of the afforestation works are concentrated in low rainfall areas where grass is an important stable formation. Therefore, introduction of better variety of fodder grass should also form an integral part of the afforestation scheme and preliminary research in this direction is indicated.

Tending and other silvicultural practices :

Since thick line sowing is adopted, it is found that cleaning is necessary, generally from third year. With a view to avoid waste of seed attended upon thick line sowings and to avoid suppression of seedlings due to root and shoot competition, orders have been issued to sow at 3" to 4" apart in the line.

Since large quantities of seeds are required in Afforestation Schemes, greater attention in cleaning and storage of seed, needs to be paid. This aspect needs more emphasis and full use of rat-poisons and insecticides such as DDT or 2% Dialdrex powder should be used to keep the seed free from damage in storage. While weeding, it is seen that grass and other weeds are generally cut by sickles but true weeding should consist of uprooting the weeds.

With a view not to wound or injure the root-system of seedlings while soil working, it may be desirable to provide small handforks to the labourers departmentally.

In some of the Afforestation areas, it is found that the different species are intimately mixed on lines, thus causing some difficulty in carrying out cleaning operation. It may be worth considering that mix uses of species, each occupying not less than a continous stretch of 6' in the line, so that the cleaning work will be simplified.

It is too premature to prescribe any thinning programme in Afforestation areas. The thinning interval will depend upon the initial spacing of plants, the rapidity of growth both in height and crown development. Therefore it will be necessary to evolve suitable thinning regime for each type area according to local experience.

General—Manuring in Forestry Practice :

At present no measuring is adopted in any of the Afforestation Schemes, inspite of the poor soil conditions, use of cowdung or compose manure for raising important species like Sal, Bamboo, etc. appears to be a regular feature in afforestation of poor and eroded soils in Bengal. It may therefore be worthwhile considering suitable manurial practices in Afforestation, specially in eroded lateritic areas of Ratnagiri, where cashew is an economically important crop. At present the work of the Forest Department is judged by Government mainly on the success of Afforestation Schemes and a little additional expenditure in manuring important and economic species under poor and degraded soil conditions, should not be grudged if success is our main aim.

BIBLIOGRAPHY

1. Techniques of afforestation of Waste lands in Arid Zone and Dry Scrub Jungle areas in India—issued by Ministry of Agriculture, Government of India.
2. Dry Zone Afforestation in Bombay State by Shri R. R. Chaudhary.
3. Afforestation Technique for the Laterite Zone in West Bengal.

ECOLOGY OF POLLUTED STREAMS WITH REFERENCE TO FISH-LIFE

By

A. DAVID

Central Inland Fisheries Research Sub Station, Allahabad

INTRODUCTION

Life-history and environmental relationship studies concerning a fish or a group of fishes, constitutes the chief work of any fisheries biologist. Why some particular species of fish should be present or absent in a stream, river or lake, and what physico-chemical, hydrological and biotal factors determine their well being, are some of the questions posed to him--particularly by agencies which concern with development of a water sheet for fish production or fish conservation.

Capacity of our inland water resources, *i.e.* rivers, streams, lakes or tidal estuaries to hold fish is not unlimited when compared to the vast marine element. Inland waters are affected by man more readily and are amenable to certain measures easily. They have limited resources and with huge multipurpose river valley projects necessitating construction of dams, weirs or barrages or the rapid pace of industrial expansion close to water resources, the riverine environments undergo drastic changes creating in most cases ecological inbalance of aquatic life, including fish.

Only within the last decade or two the knowledge concerning fresh water life in Indian waters inclusive of fish, has advanced appreciably. The exclusive trends of merely recording the taxonomy and isolated features of biology of an organism or a group, is progressively giving rise to a more dynamic study of the ecological relationships. Work of a fisheries biologist is consequently become more exacting in as much as he is now concerned with most of the intricate physical and chemical factors and other biota affecting fish biology. Just as man's life terrestrially is ultimate and is impinged upon and determined by climatological and physical factors, as well as the natural wealth of forests and other animals surrounding him, so also fish life is the ultimate result of conditions operating in the medium of water.

Importance of fish environmental studies :

Fishing industry--or commercial fishing as applied mainly to inland waters, is dependent upon natural crops taken from the rivers. Very little has been achieved in India to control the quantity, variety and sizes of fish removed from inland water sheets. An accumulation of knowledge concerning natural history of various fishes and of ecological forces operating on their life cycles, is therefore essential. But for the adequacy of this knowledge, all attempts at obtaining maximum sustained fish yields from rivers and streams are likely to spell the ruination of such resources.

Management of a fish pond--or *pisciculture* (an aspect *aquiculture*) is similar in most ways to cultivation of land for food crops. In a fish pond, ecological conditions are of a limited nature, as the bio-mass is not too open to influences from afar as in a river or even a lake. Nevertheless a pond is as complicated in detail

as any cultivated piece of land, and is as much subjected to immediate control by man, responding quickly to any measures he cares to apply.

Further ponds are experimental grounds, and offer tangible proofs of relationships that exist in a river or a large lake. For example, richer the nourishment in a pond for micro-organisms and other invertebrate animals and plants by the presence of nitrogen and phosphorus salts, richer will be fish growth and hence its production. If similar conditions in a large sheet of water, say a river are present, it can confidently be concluded that certain basic factors are favourable.

Features of life history in ecological studies :

The ecological factors that basically concern a fish are many-fold, and the salient features include the following elements :

Description of Fish and its Taxonomy	... Distinguishing features, morphology, stocks :
Distribution and Range	... Zoo-geographical factors affecting distribution (floods, temperature, altitudes etc.), habitats and association :
Food and Feeding	... At different stages of life, selectivity in food, seasonal variation in quality and numbers, periodicity and manner :
Growth	... Factors influencing growth, abunance of food, overcrowding, unsuitability of medium :
Reproduction	... Attainment of maturity, fecundity, survival of young or parents :
Embryological and Larval Development	... Factors influencing development, period survival :
Behaviour	... Movements, migrations territoriality, relations with associated species :
Populations	... Rate of mortality or survival, recruitment and gear efficiency :
Diseases	... Pathology, pollution :
Predators and Competitors	... Inter-relationships :
Relation with Man	... Value as food, game, biological control, conservation.

This requires a first hand knowledge of most groups of aquatic animals and plants.

The basic complaints heard in recent years relate to shortage of fishes in the rivers. Is depletion due to (*i*) Over fishing, (*ii*) Under exploitation, (*iii*) Killing of brood and young fishes close to barrages, headworks and similar obstructions, (*iv*) Industrial pollutions or (*v*) Combination of one or more of these factors, are some of the questions to be answered by a fisheries biologist.

Since it is beyond the scope of this dessertation to satisfactorily deal with all these aspects, discussions are confined to aquatic ecology of polluted rivers. Rapid pace of industrialisation and growth of townships along our rivers have endangered not only the potability of the waters—mainly a public health measure, but also has affected fish life.

Tyes of Stream Pollution :

"Piosonous", "Noxious" and "Polluting" are the terms freely used where trade and domestic wastes are concerned. "Poisonous" indicates danger or destruction to life, human, animal or plant ; "Noxious" is lower in degree signifying some injury, but not dangerous ; "Polluting" denotes both qualities of "Poisonous" and ' Noxious" as also offensiveness to the aesthetic senses. The fact of polluting is that of fouling a stream and introduction of impurity.

Before going into biological aspects of pollution, it is essential that agencies that cause it should be known. They are the following :

1. *Natural Pollution.*—These are accidental or occasional. Atmospheric pollution close to industrial vicinities or precipitation by rainfalls of gases thrown out into the atmosphere, cause certain degree of pollution as also the soil or silt stripped by heavy rainfalls, melting snow, leaching of salts and other similar factors. There is some pollution always by decay of animals and plants in a stream.

All above causes may be ignored for practical purposes in this study.

2. *Agricultural Pollution.*—Insecticides and herbicides used in agricultural activities and fertilisers may often during rains, be washed into rivers. Forests sprayed with insecticides like D.D.T. have showed in their streams a denudation of fish, because fish starved to death as all aquatic insects and their larvae which formed their food, died. Such examples are found in scroes in the U. S. A. and Canada.

3. *Municipal Pollution.*—This is primarily sewage pollution. In India almost all towns and cities situated on the river banks, throw such wastes into rivers. Cities like Bombay or Madras lead sewage into the sea. Calcutta sewage is lead into a tidal estuary with considerable economic loss to fish life. (David, 1960).

4. *Mining Pollution.*—Mining and mineral processing always are sources of danger to fish life. Both solids and toxic materials are generated *e.g.* coal mines and washeries. Heavy metal salts like copper, lead, zinc etc., are very highly toxic to fish. Recovery processes in extracting petroleum from oil wells throw out both oil wastes which act as thin cover over the surface ; brine that is let out can kill fresh water fish. (For each barrel of oil produced, equal amount of brine is let out). These hazards will become more potent in India close to the proposed oil refineries.

5. *Industrial Pollution.*—Textiles, tanneries, ferrous and non-ferrous metals, chemicals, fertilisers, paper and pulp, gas coke ovens, tar bases, sugar and distillaries etc., are some of the existing generators of pollutional wastes in India.

Biological considerations in Pollution :

Apart from chemical and biological considerations, pollutional effects add to clear waters, turbidity, colour, odour, taste and such undesirable qualities. These affect not only the quality of the water for domestic use, but render purification difficult. Anaesthetic considerations are confronted as such waters effect bathing, washing and drinking for miles below points of admixtures. Most times, these turn into major nuisance values.

As known well, sewage adds pathogenic bacteria and may cause epidemics of diseases. To mention only a few, Poliomyelitis, Cholera, Typhoid, Dysentry, Jaundice, Anthrax, Bilharzia, Tape worm or Nematode incidences whether of bacteria, virus or parasitical, are spread by sewage contamination. Poisoning from chemical wastes such as lead, copper, cyanide and related toxic substances may create very dangerous situations.

Even before the above hazards to human life manifest, fish and other aquatic life of a river stream are affected. Many poisonous substances kill fish and other organic life outright. Quite a few are absorbed by fish which live in or close to polluted waters. (*tolerant* or *resistant* forms). Fish in the river Bhadra had absorbed odours and turned yellowish, because of absorption of sulphur compounds from the pulp and paper mills. (David 1957). These also fetched lower prices. Similarly the surviving fishes in the Kulti estuary close to Calcutta possess very unpleasant odours. (David, 1960). Instances are not rare where epidemics of Typhoid have broken out after eating oysters contaminated by sewage. In the Prince Edward Island in Canada, a type of paralysis of limbs occurs if oysters collected from the estuaries contaminated by sewage are eaten. In India, dangers inherant in river, tidal estuarine or foreshore seas polluted by sewage or other wastes are yet to be appreciated more fully.

Even though river pollution is caused by chemical or physical agencies it is essentially a biological phenomenon. Pollution measurements in the past have been attempted on bio-chemical, chemical and physical standards. Direct measurement of pollution is the total effect of polluting substance has on plant and animal life in a stream, although chemical analysis and bio chemical and physical tests may be necessary to explain those effects.

All plants and animals exist in complex communities in a state of dynamic balance within a river or a stream. A stable equilibrium is hardly to be expected as there are various factors which affect abundance of any particular member group. Because, (*i*) *Physical and chemical nature of water*, (*ii*) *Nature of stream bed* and (*iii*) *Current*, determine proliferation or scarcity of groups or individuals. Any substance although inert and non-toxic, that changes the stream bed altering the normal life of a river is a pollutant. (*e.g.* silt, sand or sludge deposits). If colour and temperature are changed which bring out an inbalance in communities, again it is termed as due to pollutional agents. With severe pollution by liquors containing toxic substances, all plants and animals may be killed. With less severe pollution such as by liquors containing organic matters, results are more complex. Chief effect of directly non-toxic discharges on plants, are due to nutrient substances, discharged in the liquor or formed by decomposition of organic matter after discharge. These in turn affect the aquatic animals—particularly those that live in association with plants or over the stream bed, or that burrow on the bottom. Further, availability of food and oxygen, and chemical nature of water, are among the important factors determining the communities in a stream. Discharge of decomposable complex organic matter such as sewage, alters the plant and animal community depending upon the degree of pollution.

All rivers tend to overcome pollution. But for this inherent capacity, the Ganga could be the most polluted of all rivers in India, as also the Damodar and a few other streams which flow through major industrial mining belts. Self-purification (whether terrestrial or aquatic) is one of Nature's remarkable workings, leading eventually to the elimination of organic pollution. This is brought about by bio-chemical reaction, by the activities of micro-organisms, especially bacteria, which given sufficient oxygen, utilise the organic matter as food and break-down complex compounds to simpler and harmless end products. For example, autotrophic bacteria reduce the organic compounds to simpler carbon-di-oxide, cabonates or bicarbonates. These bacteria derive their energy from oxidation of ammonia, sulphides and other compounds. Both autotrophic bacteria which require oxygen for such break-down processes and anaerobic bacteria which utilise oxygen present in the organic compound itself, become active in water

polluted by organic wastes. Even lignin, cellulose, rubber, paraffin, vaseline, benzene and lubricating oils, which look so unpromising, can be broken down by bacteria which are all saprophytic. These activities of bacteria, from the basis for all recovery processes noted in a river, because several food chains with grazing animals thriving upon them start with bacteria.

Depletion of oxygen results in water containing a high organic load because bacteria use up all available oxygen during the processes of break-down, automatically limiting the number of species, which at first make use of the increased food supply. But at the same time they can live in waters deficient in oxygen. In the absence of severe intra-specific competation, these animals multiply rapidly and therefore are found in huge numbers (*e.g. Tubificid* Oligochaetes). As supply of oxygen increases, more species become established. An increased mineral content, also provides for a rich growth of vegetation.

Observing the 'outfall' region of any waste products on the bank of a river and following the course downstream, normally three zones can be observed.

I. *Zone of Immediate Pollution* or *Poly-saprobic* or *Septic Zone.*

II. *Recovery Zone* or *Meso-saprobic Zone.* Sometimes this is sub-divided into *α-Meso-saprobic β-Meso-saprobic Zones.*

III. *Zone of Completed Recovery* or *Oligo-saprobic Zone.*

These zones are long or short in a given stretch, depending upon the intensity of polluting substances and on volume and temperature of the stream. Distinct zonations as snch are possible in a rievr flowing in a single direction ; but in the tidal part of a rievr, or its estuary, as in the Kulti close to Calcutta, (David 1960), mixing of effluents is rarely perfect on account of the peculiarities of ebb and tide, and intermixing nature of fresh and brackish waters which differ in densities. Effluent discharged at flow tide currents is carried above the point of origin for miles but is brought down again during ebb tide and oscillates within the region instead of being carried away to the sea. Due to regularity of the tides, which bring about changes in levels of 12–24 feet twice during a period of 24 hours, movements of sub-stratum, high velocities and so on, no permanent settling is possible. Consequently different criteria of expressions have to be used in tidal waters. Normally in fresh waters, the above zonations generally hold good and feature the following characteristics.

Zone of Immediate Pollution

In this area, an accumulation of pollutants occurs imparting colour and odour to the receiving water. A high concentration of complex, decomposable organic matter is evidenced if the pollution is from sewage and industrial pollution generated from organic materials. But if purely hemical *e.g.*, certain mining wastes of heavy metals--lead, copper, zinic, chromium or certain very toxic wastes from coke ovens like phenols, cyanides and related poisions are present, all organisms are wiped out, rendering the river barren. This is because the primary biotic reaction caused by bacteria is inhibited as bacteria themselves are destroyed. This possibility is rare in India. If in many industrial wastes, traces of such salts are present, they retard bacterial activity until more dilution is effected, or other elements are added to neutralise the original effects.

Oxygen is completely absent if due to organic pollution ; if certain substances such as detergents, dyes, etc., are present they kill organisms by direct toxicity. Studies so far made on pulp and paper mills, (David, 1957, 1960 ; Klein, 1957 ;

individuals. Also, such healthy conditions should offer habitats suitable to many different species. Competition would be severe, and minor differences in ecological conditions would limit suitable niches and do not permit survival to only one species in large numbers.

On the other hand, pollutional conditions would eliminate many species and those that survive, lacking competition, multiply to huge numbers. A sudden reduction in species number and a great abundance of those remaining—which are called 'resistant' forms is noticed below such pollution.

Effects on Fish-life :

Ultimately fish life in river water is affected by the biological considerations mentioned earlier or by direct effects attributable to substances present in the wastes.

Direct Causes of Fish-kills :

(*i*) *Increase in osmotic pressure.* An increase in salinity by an addition of brine wastes from an oil refinery may prove dangerous to fresh water fishes. Similar situations may arise by additions of some other salts which affect osmotic regulation in fishes.

(*ii*) *Acidity or alkalinity changes.* Fish can withstand a wide range of pH, but excess of alkalinity or acidity in water proves lethal. Mucus secretion is increased on the gills or removed, both of which cause interfere with the intake of oxygen. Coal ash from thermal generating stations and pickling liquors from iron and steel works are examples.

(*iii*) *Deposition of Suspensoids and choking of gills.* Breathing in fish is affected below pulp and paper factories or coal washeries, where the finely suspended particles and fibres deposit on the gills during opercular movements, choking the fish to death.

(*iv*) *Oxygen dificiency.* A decrease in dissolved oxygen content (D. O.) due to fermentable wastes, high B. O. D. (*e.g.* distillary wastes) and other causes which remove oxygen by addition of wastes, result in an inadequacy to fishes. This results in the fishes soon beginning to gasp for breath, turning turtle and dying. Such asphyxiation is a primary and most frequent cause of death in rivers and streams of majority of fishes except some air-breathing species.

(*v*) *Specific Toxicity.* Some agents kill fish directly if present in the wastes. Corrosives like alkalies or acids, injure the gills by coagulating the mucus and gill secretions. No recovery is possible in such cases. Many substances cause death after being absorbed through the gills. Heavy metallic salts are not easy of removal from surface waters. Copper, mercury, lead or zinc, even in minute doses are absorbed and interfere with the metabolic activites of the body tissues, forming complex compounds resisting absorbtion of oxygen. Some organic acids (oxalic, acetic, formic and so on) penetrate the tissues directly, producing acute congestion of gills and forming insoluble salts in the blood. In fact most of them impair the ability of fish to absorb oxygen. Hydrogen sulphide, sulphur compounds and cyanides produce inhibitory effects upon the enzymatic oxidative processes, rendering tissues incapable of using oxygen brought by the blood. Gas works and coke oven plants produce ammonia, phenols, pyroligneous liquour, tar bases etc., which again act as internal poisons. List is inexhaustible as various chemicals have one or the other effect. Some even act upon the nervous system of fish proving slow or fast narcotical agents. Chlorine, arsenic compounds, tar products, mercaptans and some others whose numbers are still increasing, act variously on fish.

Indirect Effects :

(*i*) *Fish shelters are affected.* Deposition of sludge and other chemical precipitates on the bottom of a stream, drive away fish to more congenial surroundings. Turbidity increase, impartation of colour or odour will have the same effect.

(*ii*) *Food and Feeding are interfered with.* Destruction of plankton, insect life, addition of chemicals to the soft ooze, decay and disappearance of vegetation and similar changes, affect fish-food, therby driving away fish to other suitable environments.

(*iii*) *Insidious attraction of Fishes.* Some fish species are unable to recognise certain poisons especially if they are also compounded with organic pollution. They may be attracted to the region of pollution by an increased amount of food lower down in the recovery zone. As they migrate progressively in search of food, they are rapidly overcome by poisons. Such conditions have been observed even in Indian rivers.

(*iv*) *Spawning grounds are affected.* Fishes require certain conditions for spawning like, clear water, clean bottom, good amount of dissolved oxygen, large numbers of micro-organisms as food for the hatchlings etc. ; most of these conditions are chnaged by pollutants rendering the river stretch unsuitable for spawning

(*v*) *Migratory channel becomes closed.* As fishes move from place to place exhibiting short or long range migrations in search of food, shelter, avoidence of floods or even spawning grounds, any polluted stretch of a river or stream either drives away the fishes complicating the fishery conditions probably within the entire river.

(*vi*) *Accelerated aging of Fishery waters.* Deposits of sludge and chemical salts and presence of fungi and filamentous algae, may encourage deposition of silt affecting the regime of the stream or river considerably.

(*vii*) *Ill-effects of algal blooms and sewage fungi.* Algal blooms or sewage 'fungi' periodically die out due to one reason or the other. At such times there is a great demand on dissolved oxygen in the water far from the source of original pollution. A mass destruction of all fish may then occur.

(*viii*) *Fish seed supply is cut-off.* If the fresh water stream close to the pollutional area is used for fish 'seed' (larval stages, fry or finger lings) supply for culturable ponds, considerable economic loss may result. In the tidal Kulti close to Calcutta, almost all fish is eliminated and the natural supply of fish seed into brackish 'bheris'is stopped. (David, 1960).

In conclusion, it may be said that studies on a given river pollution have to be based upon individual conditions which are usually complex. Any standards set up purely on physico chemical and bacteriological features, deserve little merit unless the entire bio-mass also is taken into account. Bio-assays using representative species of fishes to determine the lethal extent of any substance or a series of substances of an effluent, have also to be undertaken along with such studies. Only then recommendations directed towards abatement of pollutional hazards within a stream, can be effective and scientifically more accurate.

REFERENCES

David, A. 1957. Studies on the pollution of the Bhadra river fisheries at Bhadravathi (Mysore State) with industrial effluents. *Proc. Nat. Inst. Sci. India*, **22** : 132–169.

——— 1960. Effects of Calcutta sewage upon the fisheries of the Kulti estuary and connected cultivated fisheries. *J. Asi. Soc.* (In press).

Klein, Louis, 1957. *Aspects of river pollution.* Butterworths Scientific publications, London (1957).

Motwani, M. P., Banerjea S. M. and Karamchandani, S. J. 1956. Some observations on the pollution of the river Sone by factory effluents at Dalmianagar, Bihar. *Ind. J. Fish.* **3** : 334–367.

NEW APPROACHES TO APPLIED TERMITOLOGICAL RESEACHES IN INDIA

By

J. C. BASU CHOUDHURI

Forest Reasearch Centre, Coimbatore

INTRODUCTION

The importance of the study of termites needs no emphasis. Roonwal mentioned that—"Termites provide good materials for investigating certain fascinating biological problems in many fields which are still unresolved". Besides its scientific value, the study of termites has parctical applications in agriculture, forestry, timber industries, public works and engineering departments. ,In a country like India, where industry is rapidly developing and progressing—timber and other forest products play a significant role in the life and economy of the country. The use of timbers in building constructions have not yet been replaced by ferrous structures. The demand for timber is steadily increasing. Standing forest trees, timbers under conversion and timbers for building purposes and other establishments are invariably exposed to termite infestations of varying magnitude. No comprehensive report has been prepared in India which attempts to evaluate the extent of damage caused to forest trees and timbers of different kinds (commercial, domestic and fuel wood) by destructive termites. To fight and eradicate the termite menace we have to arm ourselves with better and improved fighting devices. To achieve this aim it is necessary that we intensify terimte research programmes with special reference to forestry and other dependent industries from fundental and applied aspects. In order to prescribe effective prophylactic and control measures we have to make serious and concerted efforts to fill up the lacunae that exist in our knowledge of termite fauna of the regions concerned.

SUGGESTIONS

The suggestions outlined below will justify the need of sustained investigation on termites embracing all aspects. The cumulative data from such studies will modify our approach to applied termitology.

Taxonomic studies :

Two important research Centres in India namely, the Z. S. I. Termite Unit at Calcutta and the I. C. A. R. Termite Taxonomic Scheme at Dehra Dun are conducting studies on the systematics of the oriental termites. Hence, it will be of no immediate gain to duplicate similar studies elsewhere. A close collaboration with the competent investigators working in these taxonomic centres will provide authoritative identification characters to the economic entomologists who are engaged in other phases of termite investigations.

Need for biological and behavioural studies :

Our knowledge of biology and behaviour of termites is incomplete. A thorough investigation of termites in nature as well as under laboratory conditions taking into consideration humidity, temperature, light and nutritional factors is needed to understand the behaviour of the insect.

(*a*) *Accelerated tests* : The results of such experimental findings concerning the beahviour of termites may help in developing a method which may be designated as the "accelerated test". The accelerated tests aim to—

(*i*) device a suitable technique to estimate damage caused to timber by termites from qualitative and quantitative stand points,

(*ii*) determination of factors responsible for attributing termites resistance to certain species of commercial timbers,

(*iii*) determining the efficacy of wood-preservatives,

(*iv*) develop chemical formulations which can act as specific insecticides to termites and determining their effective dosages.

(*b*) *Grave-yard tests* : The method in vogue, in India, to evaluate the termite damage to commercial timbers and to study their susceptibility to termite attack is determined by the "grave-yard test". Such studies in the past have accumulated useful and data based on which suitable measures have been prescribed from time to time. These tests suffer from certain inherent limitations. These shortcomings render the results of the grave-yard tests as crude and superficial. Field studies on termite behaviour can modify and influence the performance of the grave-yard tests. Data concerning location of food targets, range of food, preference of feeding habits, mode of feeding, protective devices adopted by termites when exposed to natural enemies or facing adverse climatic conditions will provide information for the experimental lay-out of grave-yard tests. In spite of these refinements incorporated in designing grave-yard test, the method will still suffer from three serious handicaps namely, the long duration of test periods, degree of accuracy required and lastly the restricted scope of termite infestations to test 'blocks' by the species present in the test areas. However, these limitations can readily be corrected by conducting accelerated tests under controlled laboratory conditions. Such tests promise to provide results in precise quantitative terms within very short period.

Ecological studies on termites :

Very little work has been done in India on ecology of termites. Practically nothing is known about the quantitative ecology of termites in relation to forestry. The knowledge of the relationship which exists between the termites and their environments has a positive and practical value. It is fairly well known that termites usually differ from each other with regard to their characteristic habitat requirements, food-habits, swarming habit adaptation to various physical features of the environments, biological controlling agents, the rate of increase in population and certain other factors. After collecting data on the habits of nearly all kinds of termite species and their specific environmental requirements, it may be possible to solve the problems of termite control, to appraise any given local termite problem and to predict the nature and extent of the future termite problems in an area. The impediments for making exhaustive study of the ecology of economic species alone, are their concealed subterranean mode of living, presence of well organized caste system and lastly due to their enormous population. However, these difficulties are surmountable. Valuable information on ecology of termites can be achieved from concerted efforts by teams of investigators working for many years in different regions of the earth.

Need for physiological studies on termites :

Outcome of physiological investigations will reveal many interesting facts of considerable scientific importance *e.g.*, the role of symbiosis of microflora and microfauna in the intestines of termites, the mechanism of cellulose digestion, the function of 'fungus gardens' in termite colonies and the nutritional requirements for maintaining termite cultures in laboratories. Beside these informations we can hope to find leads of still greater importance such as—

(*a*) *Nutritional control* : The source of nitrogen in the nutritional regim of termites has baffled many competent investigators. Nitrogen acts as a strategic element to termite. Only physiological researches can disclose how nitrogen is derived by a growing termite. These studies can also give clue how to wreck or regulate the vital supply line of nitrogen available to wood feeding termites. This plausible but, difficult hypothesis can be further elaborated on physiological findings in order to develop a specific device to control termites which can be visualized as "nutritional control" of wood feeding termites. This method, if works out well, is sure to get an important place in the traditional methods adopted for insect control.

(*b*) *Radiation control* : Efforts should also be directed in exploring the possibilities of termite control by radiation method. The effect of radiation on different castes of termite society specially on the mating adults is the first step to achieve this goal.

Investigations on the chemical control of termites :

To achieve significant and effective results in controlling termite menace by chemicals it is desirable to set up a Termite Investigation Committee on the lines of San Francisco Bay Pilling Committee in U. S. A. A close cooperation between the government research organisations, insecticide manufacturing concerns and timber exploiting industries can promote field trial studies at several places simultaneously under diverse natural conditions with different kinds of treatments applied to vast array of experimental materials *e.g.*, logs piled in open shade under natural forest conditions, timber stored in lumber depots, various kinds of wood used in processing plants, structural timbers in railway and shipping yards and wood work heavily infested with termites in establishments of all kinds.

Role of termites as the builders of forest soils :

Termites have earned the reputation of being serious pests largely due to their habits of destroying and eating all kinds of plant tissues. Apart from their wanton destructions of valued timber recourses of the country some termites also constitute significant agents in building forest soils. These species contribute to a large extent in increasing the soil fertility of tropical rain forests with which we are chiefly concerned here. The slow process of soil-fertility due to termite activities is accomplished in three fold ways—

(*i*) the most efficient way in which termites break down plant debris of all kinds from standing timbers to grass mulches.

(*ii*) constantly distributing the different levels of soils of the forest floor.

(*iii*) continuous aeration of sub-soil by way of making mounds.

Unfortunately, no work of any nature has been visualised from this particular aspect of termite activity specially in the tropical rain forests of India. These

termites form an important proportion of the meiofauna of the forests floors and either by their scaverngering or destructive habits enrich the soil for better propagation of new forest crops Any project in thisdirection is sure to provide wealth of valuable data for the improvement of the silva. Thus, the syluian species of termites are as important as the domestic or arborous species. Special emphasis should be laid on the study of termites as the builders of forest soils and should have an important place in the forestry research programmes in India.

Study of termites and agricultural practices :

The role played by termites in relation to agriculture is also very significant. Further investigations are needed to throw more light on this important association. Termites counteract the agricultural practices in the following manners :

1. Termites often cause great havoc to standing agricultural crops especially to the seedlings.
2. Presence of large number of mounds cause physical obstructions to mechanical cultivation.
3. Efficient removal of vegetable littre from the surface of the ground is a serious problem more specially, in areas where humus deficiency in soil is an agricultural problem.
4. The rapid destruction by foraging termites of grass mulches designed to keep the surface cool and moist and ultimately promoting humus contents of the soil is also another serious problem.
5. Incessant destructions caused to velds and grassland countries by teeming bands of foraging termites exposes and valuable top soil to the vagaries of nature in setting-up slow and gradual process of soil erosion, in vast tracts of scrub forests and fallow lands.

The ever increasing problem of soil erosion in India can alone emphasize the urgent need and importance of devoting ourselves in the serious studies of the ubiquitous termites.

SUMMRAY

The paper aims to emphasize the importance of the study of termites from purely scientific and applied aspects. To fight and eradicate the termite menace we have to arm ourselves with better and improved fighting devices. To achieve this aim it is necessary that we make concerted efforts in understanding the ways of termites with special reference to agriculture, forestry and other human endeavours from fundamental and applied aspects.

The multi-front invasions of termites to unfoil the civilized practices leave no room to doubt for the urgent need of intensified and integrated research programmes to devote ourselves in serious studies of the ubiquitous termites.

PRELIMINARY STUDIES ON EARTHWORMS IN RELATION TO SOIL

By

P. J. DUBASH, *and* S. S. GANTI

Institute of Science, Bombay

Since the classical observations of Darwin (1881) on the role of earthworms, some new and controversial aspects have come to light, It is the purpose of this paper to review them in brief and to describe results of certain experiments devised to study its role with reference to some important soil factors.

While a majority agree in attributing a beneficial role to this animal there are a few who think otherwise (Grant, 1955 ; Agarwal *et al*, 1958). According to Grant (1955), benefical effects on crop yields observed by inoculating the living earthworms are to some extent, due to the decomposition of worms which have died during the experiment and hence, are temporary. Other arguments can be summed up as follows : (*i*) Beneficial effects displayed by earthworms can be produced equally well by artificial fertilizers ; and (*ii*) large earthworm population is the effect rather than the cause of soil fertility. Agarwal *et al* (1958) in India, observed that some species of *Allolobophora* rendered the soil unproductive by secretion of a colourless waxy fluid and made it cloddy.

The concensus of opinion, however, is in favour of earthworms. Their role as soil builders led to their being used in reclaiming flooded areas. In more advanced countries earthworm farms capable of an output of 500,000 worms a day are in operation. Contemporary work indicatesthat the major effects of earthworms on soil are : (1) improvement of soil structure (Hopp and Hopkins, 1946 ; Evans, 1948 ; Nijhavan and Kanwar, 1952 ; Zicsi, 1954), (2) favourable change in soil pH (Puh, 1941 ; Finck, 1952 ; Nye, 1955 ; Baltzer, 1955), (3) increases in mineral nutrients (Puh, 1941 ; Lunt and Jacobson, 1944 ; Hopp and Slater, 1949 ; Needham, 1957 ; Barley, 1959*b* ; Bhat *et al*, 1960), (4) increases in availability of nutrients (Puh, 1941 ; Lunt and Jacobson, 1944 ; Barley, 1959*b*) and (5) transport of sub-soil to the upper cultivable soil surface, thus counteracting the ravages of soil erosion.

Microbiological studies on the earthworm gut by Bhat and his School (Khambata and Bhat, 1957 ; Bhat *et al*, 1960) have brought to light their ability or otherwise to communicate certain pathogens. They have also proved that earthworm intestines are devoid of nitrifying bacteria, though harbouring the nitrogen fixing *Azotobactor chroococcum*. Kuhnelt (1948) maintains that plant residues must first pass through several animals before they can be made available to micro organisms, which in turn, transform them to forms acceptable to higher plants. Jacks (1955) also observes that soil animals like earthworms are more importan than micro-organisms in this respect.

The present investigation concentrated on changes produced in certain factors like total nitrogen, organic matter, and calcium carbonate, in passing through the gut of a single worm, namely, *Pheretima posthuma*, maintained as a sub-culture. The experiments were repeated with different animals of the same species. Main cultures were maintained in culture boxes according to the technique described by Tembe and Dubash (1959) which provided the stock for subcultures.

MATERIAL AND METHODS

To the unintitiated all worms look alike, but in reality they show great difference in their physiological make up which is perhaps the main reason for the contradictory observations that have been recorded in the past. The mode of excretion, the distrbution of nephridia, presence or absence of calciferous glands and other features determine a particular species. Each worm used was carefully examined for the distinguishing characters of the species. The casting of *P. pos thuma* have a pellet like appearence, varying from 1/20th to 1/10th of an inch in length. Unlike some other spp. this animal voids casting on the surface and hence becomes suitable for the type of investigation described here.

Barley (1959*a*) employed a pot culture method in studying the castings of *Allolobophora caliginosa*. An earthen plate method, a modification on that of Barley (1959*a*) was devised, whereby pure cultures could be obtained and castings collected without any contamination from ohter worms. 100 gms. of soil, free from manure, was passed through a 30 mesh B. S. sieve and mixed with shredded leaves and straw and then put in shallow culture plates 8″ in diameter. A small hole is bored in the bottom and then plugged with absorbent cotton, so as to prevent excess drainage. 25 ml. of distilled water was sprayed uniformly over the soil surface and the leaves and straw allowed to decompose for 72 hours. The earthworms were previously fed on wet filter paper for 48 hours, in order to clear their gut of any soil present (Barley, 1959*a*). They were than weighed quickly on a Mettler balance and distributed one per plate. The plates were covered with polythene to prevent excess of evaporation. After 24 hours the worms were removed, washed, wiped dry and re-weighed. The castings were separated from the soil and their moisture content, total nitrogen, organic matter and calcium carbonate determined along with that of the culture soil. The total nitrogen was determined by the micro-Kjeldahl method (Strouts *et al*, 1955) organic matter by the Walkley–Black method (Jackson, 1955) and calcium carbonate with the Collin's Calcimeter.

Results are summarised in Tables I and II.

RESULTS

TABLE 1

Faecation data of *Pheretima posthuma*

Plate No.	Wt. of worm before culturing. Grams	Wt. of worm after culturing. Grams	Wt. of air dry casting. Grams	Wt. of oven dry casting. Grams	Faecation as multiple of body weight. Times.
1	0·8791	0·8650	6·6150	5·1742	8·26
2	0·7083	0·7153	7·3483	6·8743	10·49
3	0·9470	0·9500	8·0783	7·5399	8·96
4	0·8769	0·9648	6·5100	6·1006	8·12
5	0·6897	0·7210	5·2386	4·9059	8·66
6	0·8020	0·7946	4·9893	4·6992	6·42
Mean	0·8188	0·8350	6·4630	5·8783	8·81

TABLE II

Comparative data of soil and castings

No.	% moisture		% total nitrogen		% ora. matter		% $CaCO_3$	
	Soil	Casting	Soil	Casting	Soil	Casting	Soil	Casteng
1	6·3	6·6	0·154	0·160	3·269	3·92	0·280	0·36
2	6·4	6·6	0·154	0·160	3·269	3·92	0·283	0·358
3	6·3	6·7	0·154	1·159	3·269	3·92	0·281	0·357
4	6·2	6·5	0 154	0·160				
5	6·2	6·5	0·150	0·162				
6	6·2	6·5	0·154	0·160				
Mean	6·26	6·56	0·153	0·1601	3·269	3 92	0 282	0·356

DISCUSSION

Several workers observed with species other than *Pheretima posthuma*, that an average growing animal defaecated castings equal or exceeding its own body weight in 24 hours (Hopp and Hopkins, 1946 ; Barrett, 1955 ; Barley, 1959*a*). Evans and Guild (1947) estimated the total amount of castings of a field as ranging from 7 to 11 tons/acre/year. Working separately on Rotahmsted permanent pasture soil, Evans (1948) found the amount of casting varying from 1 to 25 tons/acre/year. Roy (1958), estimated total amount of casting in Baranagore, Calcutta and Giridih, Bihar as ranging from 9 to 89 tons and 0·30 to 2·04 tons respectively per acre per year. Thus there are wide variations in the estimtes.

The resuts in Table I indicate that the amount of defaecation appaoximates eight times the body weight *P. posthuma*, in a period of 24 hours, under the conditions specified above. This high rate of defaecation has not hitherto been recorded. Guild (1955) observes that the amount of defaecation depends upon size, species complex and on the type of soil. Barley (1959*a*) considers that the age of the worm may also account for their rate of defaecation.

The increases in moisture content, total nitrogen, percentage of organic matter and calcium carbonate were statistically signifinant. The increase of total nitrogen is comparatively less than increases in the other factors studied. Barley (1959*b*) also observed a small increase of organic nitrogen in the castings but they were found to contain more available nitrogen than the soil. The increases in organic matter and calcium carbonate content of castings relative to soil were considerablc (Table II). Increase in organic matter has been reported by several other workers (Puh, 1941 ; Lunt and Jacobson, 1944 ; Nijhavan and Kanwar, 1952 ; Hasan *et al*, 1956). The augmentation of calcium carbonate in the castings of *P. posthuma* may be due to concentration rather than active secretion, since this species can at best be said to possess only by rudiments of calciferous glands (Bhal, 1936). Further work with other species having well developed claciferous glands will be taken up later. No conclusion can be drawn at present with regards to the change of weight of earthworms during the course of experiment.

The increases reported here within a short period of 24 hours, indicate the extent of progressive changes which may be occurraing in the soil through the years. Moreover the technique adopted avoids the errors due to increases produced by dead and decaying worms.

Comparative work on additional aspects of the castings *P. posthuma* and other related species of worms is in progress.

ACKNOWLEDGMENT

The authors are indebted to Dr. D. V. Bal, Director, Institutite of Science and Prof. Mrs. E. Gonzalves, Head of the Botany Department for their encouragement and help throughout the course of investigation.

REFERENCES

Agarwal, G. S., Rao, K. S. and Negi, L. S. 1958. Influence of certain spp. of earthworms on the structure of hill soils. *Curr. Sci.*, **27** : 213.

Bahl, K. N. 1936. Pheretima. *Indian Zool. Mem.* (Luck.) 2nd Edition p 31.

Baltzer, R. 1955. Earthworm population and soil type. *Z. PflErnahr. Dung.* **71** : 246.

Barley, K. P. 1959. The influence of earthworms on soil fertility. II. Consumption of soil and organic matter by the earthworm *Allolobophora caliginosa* (Sav.) *Australian Jour. Agri. Res.* **10** (2) : 179.

Barley, K. P. and Jennings A. C. 1959. Earthworms and fertility. III. The influence of earthworms on the availability of nitrogen. *Australian Journ. Agri Res.*, **10** (3) : 364.

Bhat, J. V., Khambata S. R., Maya G. Bhat, Sastry, C. A , Rajul, V. Iyer and Iyer, V. 1960 Effects of earthworms on the microflora of the soil. *Indian Jour. Agri. Sci.*, **30** (2) : 106.

Darwin, Charles 1881. The formation of vegetable mould through the action of worms. John Murray, Albemarle Street, London.

Day, G. M. 1950. The influence of earthworms on soil micro-organisms. *Soil Sci.*, **69** (3) : 175.

Evans, A. C. 1948. Studies on the relationship between earthworms and soil fertility. II. Some effects of earthworms on soil structure. *Ann. Appl. Biol.* **35** (1) : 1.

Finck, A. 1952. Oekologische und Bodunkundliche Studien uber die Leistungen der Regenwurmer fur die Bodenfru chtbarkeit. *Zeitseher. Pflanz-enErnhar Dung. U. Bodenk* **58** (2) : 120.

Grant, W. C. Jr. 1955. Earthworm breeding farms. *Science*, **120** (3134) : 107.

Guild, W. J. McL. 1955. Earthworms and soil structure. *Soil Zoology* (*Proc. Notting Sch. Agr. Sci.*), **83**.

Hasan, A. A. G., Habib, A. and Issa, G. I. 1956. The relationship between earthworms and soil fertility. *Ann. Agri. Sci. Cairo*, **1** : 325.

Hopp, H. and Hopkins, H. T. 1946. Earthworms as a factor in the formation of water stable Soil aggregates. *Jour. oil. and Water Conser.*, **1** (1) : 11.

Hopp, H. and Slater, C. S. 1949. The effect of earthworms on the productivity of agricultural soil. *Jour. Agri. Res.* **78** (10) : 325.

Jacks, G. V. 1950. Pedology. The role of soil fauna in soil formation. *Science Progress*, **38** : 725.

Jackson, M. L. 1958. Soil Chemical Analysis. *Constable & Co. Ltd.*, Orange St. London W. C.–2. pp. 219–221.

Khambata, S. R. and Bhat, J. V. 1957. A contribution to the study of the microflora of the intestine of Indian earthworm. *Arch. Mikrobiol.* **28** : 69.

Kuhnelt, W. 1948. The role of animal kingdom in soil metabolism. *Bodenkund*, **2** (1) : 49.

Lunt, H. A. and Jacobson, H. G. M. 1944. The chemical composition of earthworm casts. *Soil Sci.*, **58** (5) : 367.

Needham, A. E. 1957. Components of nitrogenous excreta in the earthworms *Lumbricus terrestris* L. and *Eisenia foetida* (Savigny). *Jour. Expt. Biol.*, **34** : 425.

Nijhavan, S. D. and Kanwar, J. S. 1957. Physico-chemical properties of earthworm casting and their effect on the productivity of soil. *Indian Jour. Agri. Sci.*, **22** : 375.

Puh, Y. Chiung 1941. Beneficial influence of earthworms on some chemical properties of the soil. *Contr. Biol. Lab. Sci. Soc. China Zool. ser.*, **15** (9) : 145.

Roy, S. K. 1957. Studies on the activities of earthworms. *Proc. Zool. Soc. Cal.*, **10** (2) : 81.

Strouts, C. R. N., Gilfillan, J. H. and Wilson, H. N. 1955. Analytical chemistry Vol. I. Oxford Uni. Press Amen House London. E. C.–4. p. 356.

Tembe, V. B. and Dubash, P. J. 1959. A preliminary note on the culture and development of Indian earthworms. *Jour. Bom. Nat. Hist. Soc.*, **56** (3) : 643.

Zicsi, A. 1954. The role of earthworms in the soil as investigated by soil analysis, experiments on survey at the University in Godollo. *Agrataud. Egyet. agron. Kar. Kiadv.* **1** (14) : 1.

Note on Forestry and Human Ecology . . . . . *S. S. Buit* 137

Studies on Aspergilli and Penicillia of the rhizosphere of Some Crop plants . . *B. S. Mehrotra, Dinesh Kumar and V. P. Agnihotri* 139

The Effect of decomposition of mature leaves and litter of Sal (*Shorea Robusta* Gaertn. F.) on garden and lateritic Soils . . . . . *N. K. Jain* 148

Regional Imbalance in the Arid Parts of Rajasthan . *Anil Baran Bose* 153

Ecological Problems in the Tropics—Erosion in relation to Vegetation Cover in two areas of Varanasi . . . . . *R. S. Ambasht* 158

The Place of Biological Control in Forestry Research in India . . . . . *J. C. Basu Choudhuri* 163

The problem of Temperature and Humidity in relation to Tropical Insects . . . . . *U. S. Srivastava* 171

Role of Silviculture in Afforestation with special reference to Afforestation Works of Maharashtra State . . . . . *D. V. Khisty* 172

Ecology of polluted streams with reference to Fish-life . *A. David* 179

New Approaches to Applied Termitological Researches in India . . . . . *J. C. Basu Choudhuri* 189

Preliminary studies on Earthworms in relation to soil . . . . . *P. J. Dubash and S. S. Ganti* 193

Instructions to the Contributors

Manuscript should be type written in double space on one side of the paper only. Names of chemicals and not their formulae should be used in the text. Foot notes should be avoided.

Title : The title should be short and suitable for indexing. A small subtitle indicating the exact aspect of the work may also be given if the papers are published in certain series.

Tables : Table should be typed on separate sheets of paper and they should bear a brief legend. *Graphs and tables representing the same set of data should be avoided.* Structural formulae should not be included inside the Table.

Illustrations : All illustrations should be numbered consecutively. Legends should be typed on separate sheets of paper and attached at the bottom of the figure. Line drawing should be made with India ink on Bristol board or cellophane sheets. The size of letters, numbers and lines etc., should be sufficiently large to permit reduction to page size without loss of details. In case of photographs the prints must be on glossy paper and contrasty.

Summary : The summary should indicate the principal findings of the paper and normally should not exceed 250 words.

References : The references should be arranged in the following manner : Name of author/authors followed by initials. Title of the paper. This should be followed by the name of the Journal (abbreviation) with a single underline, number of volume with double underline, page number and lastly the year of publication. The following would be useful illustration :

Wolf, F. T. Nutrition and metabolism of the tobacco wilt *Fusarium*. *Bull. Torrey. Bot. Club*, **82** : 342–354, 1955.

The manuscripts which are not sent in the suggested manner will be returned to the authors.

Published by Dr. R. K. Saksena, for the National Academy of Sciences, India, Allahabad
and Printed by E. K. Raja at The Capital Printing Works, Allahabad
Secretary Editorial Board—**Dr. R. K. Saksena**

CONTENTS

		Pages
The task before the Tropical Ecologist with special references to India	*Harry G. Champion*	1
Trace element survey of some soils of India	*G. S. Puri and K. Lakshminarayanan*	6
Problems of adaptation among Herbaceous Plants of the tropics	*R. Misra*	14
Organic matter and phosphates in Land Fertility Increase	*N. R. Dhar*	16
Forestry and Soil Conservation in Maharashtra State	*D. V. Khisty*	25
Some important biotic factors operative in Sal (Shorea Robusta) Forests of Uttar Pradesh	*H. P. Bhatnagar*	37
Problems in Autecology of Weed Flora of India—1. Ecology of *Achyranthes Aspera* Linn.	*P. S. Ramakrishnan*	41
Ecological Observations on *Achyranthes Aspera* Linn.	*P. S. Ramakrishnan*	45
Chromosome Numbers and Habitats with special reference to Tropical Plants	*R. P. Patil and Krishna Ghosh*	52
Ecological problems in the Western Himalayas	*J. S. Singh and M. K. Wali*	55
Invasion of Plants in Arid Regions of India	*S. K. Jain*	58
Preliminary Observations on three Grassland Communities of Khair-Sisoo (Acacia—Dalbergia) Forests in Champaran Forest Division, Bihar	*D. M. Verma*	61
Soil-Vegetation relationships in Central India	*S. C. Pandeya*	63
Plant Introduction in the Arid Zones of India	*R. N. Kaul and B. N. Ganguli*	67
Problems on Tropical Ecology	*John H. Davis*	69
Germination Studies in *Hyptis Suaveolens* Poit. Part I—Breaking of Dormancy and effect of certain Physical Treatments on the Percentage Germination	*M. C. Saxena*	70
Ecological Studies on the Humid Tropics of the Western Ghats, India	*B. S. Ahuja and K. P. Singh*	77
The Succession on Forest Communities in the Forests of the Dehra Dun and Saharanpur Forest Divisions	*G. S. Puri*	85
Social-Economy of the Himalayan People in relation to the Forests of Garhwal Himalayas	*Raj Kumar Gupta*	104
Studies on the Vegetation of Indian Arid Zone VII—Foliar Analysis of certain Desert Plants	*B. M. Sharma*	115
General Features and Floristic Composition of Tropical Evergreen Forests of India	*H. P. Bhatnagar*	119
Need for Studies in Population Differentiation in Indian Plants	*P. S. Ramakrishnan*	126
Studies on Mangroves	*S. S. Sidhu*	129